Floodplain Management Assessment

of the Upper Mississippi River and Lower Missouri Rivers and Tributaries

US Army Corps of Engineers

June 1995

FPMA

FloodPlain Management Assessment

June 1995

Main Report

US Army Corps
of Engineers

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FLOODPLAIN MANAGEMENT ASSESSMENT
OF THE
UPPER MISSISSIPPI AND LOWER MISSOURI RIVERS
AND THEIR TRIBUTARIES

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Appendix C (Environmental)

Appendix D (Public Involvement/Institutional Factors)

Appendix E (Cultural Resources)

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a. Describe resources	1/3
b. Array desires	11
c. Array uses	3
d. Describe impact forces	2
e. Array actions	8/9
f. Hold public workshops	11
g. Document and present conclusions	12
h. Identify critical facilities needing protection	3
i. Examine differences in cost sharing	10
j. Evaluate cost effectiveness of alternatives	9
k. Recommend improvements to flood control	12

EXECUTIVE SUMMARY

The Midwest Flood of 1993 was without precedent in many respects, such as the areal extent and duration of rainfall that led to it, the severity of flooding at many locations, and the institutional response of the nation. The ensuing public attention and reaction generated Congressional authorization and appropriations for the Corps of Engineers to conduct a comprehensive, system-wide study to assess flood control and floodplain management in the areas that were flooded in 1993.

The Floodplain Management Assessment of the Upper Mississippi and Lower Missouri Rivers and their tributaries, or FPMA, was authorized by House Resolution 2423, dated November 3, 1993. Congress provided funds in the Fiscal Year 1994 Energy and Water Development Appropriations Act, which was signed into law as Public Law 103-126.

The authorizing language from Congress and subsequent guidance provided by Headquarters, U.S. Army Corps of Engineers established the following 11 objectives for the conduct of this assessment:

a) Describe resources and project future conditions;
b) Identify desires of local interests;
c) Describe varying outputs from alternative uses of floodplain resources;
d) Describe forces that impact floodplain resources;
e) Array alternative actions;
f) Evaluate and prioritize alternatives based on consultation and coordination through public workshops or similar mechanisms;
g) Prepare a report to document efforts, present conclusions, and recommend subsequent follow-on studies;
h) Identify critical facilities needing added flood protection;
i) Examine differences in Federal cost sharing on the upper and lower Mississippi River system;
j) Evaluate cost effectiveness of alternative flood control projects; and,
k) Recommend improvements to the current flood control system.

The FPMA has attempted to be responsive to these objectives while complementing the work accomplished by many others on related aspects of the floodplain issues.

Probably the most notable work by others is the report commonly referred to as the "Galloway Report". The Administration's Interagency Floodplain Management Review Committee published the report in June 1994. The committee was formed to take a fresh look at floodplain management and other policies that may have contributed to the severity of flood damages. The recommendations of the report are, as of this writing, under consideration by the Administration. Some of the needed changes in Federal flood insurance and disaster assistance programs identified in the report are already enacted into law. The FPMA has attempted to complement the Galloway Report in those areas where the Corps is uniquely qualified.

The FPMA focuses on a comparison of impacts and costs of implementing a wide array of alternative policies, programs, and structural and nonstructural measures by assuming they had been in place at the time of the 1993 flood. It explores three scenarios of changes in flood insurance, State and local floodplain regulation, flood hazard mitigation and disaster assistance, wetland restoration, and agricultural support policies. The structural alternatives ranged from levees high enough to contain the 1993 event to totally removing the levee system, with several intermediate alternatives. This approach brackets the extremes. An acceptable solution is probably somewhere in between and involves a combination of alternatives. A preliminary examination is made of the hydrologic and hydraulic effects of watershed measures and wetland restoration.

These impact analyses are based on results of systemic hydraulic computer modeling that represents an advancement in the state-of-the-art in flood analysis. This modeling work was initiated by the Corps of Engineers prior to the FPMA, but funds were also budgeted under the FPMA. Work performed for the Assessment contributed to the achievement of the first hydraulic modeling capable of predicting impacts of random changes in floodplain storage parameters (such as when a levee break occurs).

Since the beginning of the assessment in January 1994, Corps of Engineers Headquarters' direction has been to include any conclusions that data collection, hydraulic modeling, and impact evaluations could support. The goal has been to identify and evaluate alternative floodplain and flood management measures, including the effects of policy changes and modifications to the current flood damage reduction features in the areas that were flooded in 1993.

The FPMA is also unprecedented because of the high degree of cooperation and teamwork displayed not only by the five Corps of Engineers Districts (St. Paul, Rock Island, St. Louis, Kansas City, and Omaha), three Division offices (North Central, Lower Mississippi Valley, and Missouri River), and Corps Headquarters, but by the representatives of the Natural Resources Conservation Service (NRCS), the Federal Emergency Management Agency (FEMA), the U.S. Environmental Protection Agency (USEPA), the U.S. Fish and Wildlife Service (USFWS), and the states (namely Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, and Wisconsin). The contributions of data, participation in workshops, and review and comment on interim study products by these various offices helped give this assessment a breadth of perspective beyond that available from within a single agency. Three series of public meetings were held throughout the study area in June 1994, November 1994, and April 1995. Also, the Plan of Study and "Milestone Packages" were distributed in April 1994, August 1994, September 1994, and January 1995. These efforts were designed to inform and to obtain feedback on strategies, the study process, and data being used for evaluation. Adjustments to study tasks during the study period resulted from comments.

The feedback received during coordination of the assessment highlights contrasting views regarding use of the floodplain. Some groups advocate broad floodplain management concepts while others view floodplain management as being inconsistent with flood control and economic development. It is also apparent that flood fighting and associated levee raises are part of a culture of self-reliance held by many of the people who are protected by levees. Many believe that the levees constructed 50 or more years ago were adequate for hydrologic conditions at that time, but that the severity of floods has increased due to actions in the watershed that have increased runoff or because of physical changes in channel or levee capacity. Countering some of these views are the concerns about vulnerable uses of the floodplain which result in high costs of disaster relief following a flood event such as that of 1993 and contribute to adverse impacts on the natural floodplain environment. This assessment does not resolve all these issues or recommend an overall best plan. Rather, it serves as another tool in understanding the relative impacts of various potential actions.

As you review the evaluation results, findings, and conclusions please be alert to four areas of caution:

1. The 1993 flood event is used as a base condition to evaluate impacts of changes in policies and structural alternatives, recognizing that the 1993 event is still fresh in everyone's minds and provides a wealth of additional information on the region's vulnerability to extreme flood events. In addition, the 1993 flood was so widespread that an opportunity existed to evaluate varying flooding levels, ranging from a 20-year to over a 500-year event in different areas. Its areal extent and duration make it a unique flood, as every flood is. The FPMA does not provide a complete basis for formulating or recommending projects, because flood frequency analysis and evaluation of life cycle and cumulative benefits and costs must first be accomplished. These were beyond the scope of the FPMA.

2. The Findings and Conclusions of this report are those of the five Districts and three Divisions involved in the FPMA effort.

3. The results of the hydraulic modeling of the various alternatives represent approximate values that are appropriate for an overall assessment. Although further analysis could modify results to some degree, the general trends displayed in this report should remain the same. The unsteady-state modeling used for this assessment addresses the relationship between stage and discharge, but not the relationship between discharge and frequency. The flood discharge-frequency estimates for the Upper Mississippi River are based on a 1970 Federal interagency agreement. There are no current plans for revising these estimates for either the Mississippi or Missouri Rivers based on the 1993 flood or other recent floods. However, there is concern by many, including the Corps of Engineers hydrologists, that those estimates need to be revisited.

4. The data collected were almost exclusively data that were already available, such as the economic damages from the 1993 flood. Much of this data is aggregated at a county level, and is not broken down into floodplain reaches. Although there would be a higher level of confidence with data at a greater level of detail, the data used were suitable for this type of initial systemic evaluation.

Some of our more significant findings and conclusions are:

*** Structural flood protection performed as designed and prevented significant damages.**

Corps reservoirs performed well, reducing flood water elevations along the main stems of the Upper Mississippi and Lower Missouri Rivers by several feet in most locations. Structural flood protection (urban levees and floodwalls) performed as designed in protecting large urban centers. The Congressional General Accounting Office concluded that "most Corps levees performed as designed and prevented significant damages" (page 11 of report dated February 28, 1995).

*** Approximately 80% of 1993 crop damages region-wide were caused by overly saturated fields, unrelated to overbank flooding.**

At least 50 percent of the total 1993 flood damages were agricultural and approximately 80 percent of 1993 crop damages region-wide were caused by overly saturated fields or other factors unrelated to overbank flooding. These losses would not have been affected by changes in floodplain management policies. The best option to address these damages is a rational program of crop damage insurance. Crop insurance reform legislation (Title I of PL 103-354) was enacted late in 1994.

*** Flood damages in urban floodplains with inadequate or no flood protection continue to be a major problem.**

For the 120 counties adjacent to the Upper Mississippi and Lower Missouri Rivers and several of their major tributaries that were the focus of this assessment, urban damages substantially exceeded agricultural losses. Overbank flooding and problems associated with urban drainage and stormwater runoff continue to occur in a number of locations, as confirmed by the 1993 event.

*** No single alternative provides beneficial results throughout the system.**

From a hydraulic evaluation perspective, the FPMA analysis illustrates that no single alternative provides beneficial results throughout the system. Applying a single policy system wide may cause undesirable consequences at some locations. Examination of many factors such as computed peak stages, discharges, flooded area extent, and depth within flooded areas is necessary to evaluate how an alternative affects performance of the flood damage reduction system as a whole.

*** It is essential to evaluate hydraulic impacts systemically.**

The importance of evaluating hydraulic impacts systemically is clear from the results of the unsteady-state hydraulic modeling. Changes that affect the timing of flood peaks or the "roughness coefficients" of the floodplain can be as significant as changes in storage volume.

*** If all agricultural levees had been successfully raised and strengthened, urban flood protection would have been placed at much greater risk.**

If the agricultural levees along the Upper and Middle Mississippi River had been raised and strengthened to prevent overtopping in the 1993 event, the flood stages on the Middle Mississippi would have been an average of about 6 feet higher. Likewise, raising the levees to prevent overtopping on the Missouri River would have increased the stage by an average of 3 to 4 feet, with a maximum of 7.2 feet at Rulo, Nebraska, and 6.9 feet at Waverly, Missouri.

*** Flood stage changes resulting from the removal of agricultural levees are highly dependent on subsequent use of the floodplain.**

Hydraulic routings, assuming agricultural levees are removed show that, with continued farming in the floodplain, 1993 stages would be reduced an average 2 to 4 feet on the Mississippi River in the St. Louis District (middle Mississippi River). If this area would have returned to natural forested conditions, some of the system would still have shown reductions in stage (up to 2.8 feet), but increases in stages by up to 1.3 feet would also be seen in some locations. In the Kansas City District (lower Missouri River), hydraulic modeling shows changes in stages of -3 to +1 foot for no levees with agricultural use and -3 to +4.5 change with forested floodplains.

*** Restoration of floodplain wetlands would have little impact on floods the magnitude of the 1993 event. Agricultural use of the floodplain is appropriate if risk of flooding is understood and accepted.**

Converting floodplain agricultural land to natural floodplain vegetation would not reduce stages in some locations but would marginally reduce damage payments in the 1993 Midwest Flood. Agricultural use of the floodplain is appropriate when the residual damage of flooding is understood and accepted within a financially sound program of crop insurance and flood damage reduction measures and when it is compatible with essential natural floodplain functions. Current theories on floodplain function predict that the area needed for an improvement to the natural biota is probably fairly small and that restoration of a series of natural floodplain patches (a string of beads) connected by more restricted river corridors would be practical and beneficial.

*** Restoration of upland wetlands would have produced localized flood reduction and other benefits, but little effect on main stem flooding.**

Hydraulic modeling of reducing the runoff from the upland watersheds by 5 and 10 percent predicted average stage decreases of about 0.7 and 1.6 feet, respectively, on the Upper and Middle Mississippi River and about 0.4 and 0.9 feet, respectively, on the Lower Missouri River. However, wetland restoration measures alone would not have achieved this level of runoff reduction for the 1993 event because of the extremely wet antecedent conditions. Restoration of upland wetlands would produce localized flood reduction benefits, but have little effect on mainstem flooding caused by the 1993 event. There are other reasons for why restoration of upland wetlands is very important, such as reduced agricultural exposure to flood damage, water quality, reduced sedimentation, and increased wildlife habitat.

*** State and local floodplain zoning can be an effective means of siting critical facilities out of harm's way.**

State and local floodplain zoning ordinances and regulations could be most effective in determining the siting of critical facilities that have the potential for releasing toxic or hazardous elements into the environment when flooded.

*** More extensive reliance on flood insurance would better assure appropriate responsibility for flood damages.**

More extensive reliance on flood insurance would better assure that those who invest, build, and live in the floodplain accept appropriate responsibility for the damages and other losses that result from floods. Expenditures for the 1993 flood through the National Flood Insurance Program and the Federal Crop Insurance Corporation were less than half of total disaster aid payments.

*** Greater emphasis on flood hazard mitigation actions is justified.**

More emphasis is now being placed on use of flood hazard mitigation measures, especially acquisitions of flood-prone structures, as an action that will reduce repeated Federal disaster expenditures and other costs associated with areas of widespread and potentially substantial repetitive flooding.

*** Although there are conflicting public viewpoints on uses of the floodplain, areas of potential agreement exist and need to be pursued.**

Comments heard and read from the public throughout the assessment followed three main themes, with varying degrees of acceptance among the interest groups:

a) Importance of agricultural levees;

b) Need for shifted emphasis to non-structural measures and upland watershed measures; and,

c) Need for greater coordination among agencies responsible for managing the upper Mississippi and lower Missouri Rivers.

*** Better adherence to existing policies is a necessary, immediate, and effective first step for better floodplain management.**

Measures that would reduce damages during future floods that are not dependent upon any revised policies and programs include:

a) Good maintenance of both the existing Federal and non-Federal levee system.

b) State and local interests enforcing land use policies to ensure that new floodplain development does not occur or is constructed to minimize damage potential (raising, floodproofing, etc.)

*** Examples of shifting dependence from disaster aid to flood hazard mitigation and flood insurance are justified.**

A shift from dependence on disaster aid to flood hazard mitigation (floodproofing, elevating, or acquiring and relocating out of the floodplain) and flood insurance appears to be occurring. The following examples of measures that warrant further consideration generally follow the Federal philosophy of floodplain management which recognizes that flood damage avoidance should generally be the first defense against flooding, complemented by nonstructural and structural flood protection measures, where appropriate, with public education and flood insurance included as essential components to address the residual risk of flooding:

a) acquisition of structures that are repetitively damaged;

b) more widespread and stricter enforcement of flood insurance requirements for individuals, farmers, businesses, and communities (already well underway);

c) enforcing strict consistency in eligibility for the provision of disaster aid;

d) greatly increased emphasis on flood hazard mitigation planning and implementation;

e) assuring that communities and individuals are aware of the degree of risk involved in residing behind a levee or downstream of a dam in a floodplain, especially if less than Standard Project Flood (SPF) level of protection;

f) more effective floodplain management policies and zoning standards at the local level to prevent floodprone development;

g) an expanded boundary for flood risk zones to go beyond designation of "100-year" flood zones for flood insurance;

h) more upland watershed retention measures that will hold or slow rainfall runoff; and,

i) continue structural protection when systemic analysis of impacts and life cycle costs indicate this is the best solution, but with an awareness of the risks associated with induced development.

*** Preparation for even larger floods is needed.**

Floods greater than the 1993 flood catastrophe will happen in the future. It would be prudent to prepare for future floods larger that the 1993 event. When we are properly prepared for catastrophic flood events, smaller floods will be more easily accommodated.

*** Much valuable data such as hydraulic modeling, mapping, and data inventories resulted from the assessment study.**

The hydraulic modeling, the gathering and organizing of data and viewpoints, and the evaluation of this input for the FPMA should provide an improved understanding of many floodplain management issues. The FPMA has played a part in helping to develop many new "tools" for those involved in making floodplain management decisions. There is now a working unsteady state flow hydraulic model on the Upper Mississippi and Lower Missouri Rivers, digitized land use mapping, an environmental resource inventory, and other products, as listed in Chapter 12 of the report.

Through the FPMA analyses, the following efforts are considered to have greatest value in furthering future understanding and enhancing sound floodplain management directions:

a) Inventory and spatial database of levees and other structures in the floodplain;

b) Inventory and GIS database of critical facilities in the floodplain;

c) Additional hydraulic modeling (unsteady state) with more detailed mapping and coverage over portions of the main stem rivers not yet modeled and for the larger tributaries. (A system model, including the Mississippi, Missouri, Illinois, Ohio, and Arkansas Rivers is scheduled to be available by the end of Fiscal Year 1996);

d) A real-time, unsteady state hydraulic model and tributary rainfall runoff forecasting models for predicting flood crests in future flood emergencies.
e) Updated hydrology and hydraulics data, including discharge-frequency relationships and water surface profiles.
f) More extensive data and hydraulic modeling of upland watershed areas that have the greatest potential for flood damage reduction;
g) Development and experimental testing of biological response models that are linked to existing hydraulic and hydrologic models;
h) If a system-wide plan for flood damage reduction is desired, economic data must be collected, indicating the specific locations and elevations of damageable property; and,
i) Maintain and update the environmental GIS data base that has been developed in this effort. This data base can serve as an important resource in developing floodplain management strategies for specific reaches and in developing a systemic management plan for natural resources.

As stated earlier, this assessment was limited in its evaluation to comparing impacts of a wide array of policies, programs, and flood damage reduction measures to only a single event, the Midwest Flood of 1993. To develop recommendations or a comprehensive floodplain management plan, either system-wide or for specific reaches, would require a more complete analysis. Such an analysis would ideally include impacts of all possible flood events, life cycle and cumulative costs and benefits, and a more quantitative measurement of impact categories such as environmental, social, human trauma, and cultural. However, this assessment has taken an important step toward achieving a better understanding of the current uses of the floodplain, forces causing those uses, and impacts of various alternative changes in the management of the floodplains.

The bottom line of the assessment was probably best stated in one of the comment letters on the draft report which says, "the assessment validates the view that while structural flood control measures are an important part of an overall floodplain management program, they have limitations and floodplains are best managed through a combination of structural and non-structural measures that fully recognize the inherent risk of occupying flood hazard areas".

INTRODUCTION

General

The Midwest Flood of 1993 resulted in one of the most costly flood disasters in United States history. There were catastrophic damages to residential, commercial, industrial, agricultural, and public properties in large portions of the upper Mississippi and lower Missouri Rivers and their tributaries. While many flood damage reduction measures reduced or prevented damages to many properties, these measures often were not designed to withstand the magnitude of flooding experienced during 1993. The extent of damages resulting from the 1993 flood raised such questions as:

- What is an appropriate level of flood protection?
- Did flood protection measures or existing Federal policies have any adverse impacts, including the inducement of higher levels of damage?
- What policies would lead to the best long-term Federal investment in the floodplain?
- What is the best means of reducing impacts in the floodplain from future floods?
- What is the appropriate role of agricultural levees in the floodplain?

The ensuing public discussions generated Congressional authorization and appropriations for the Corps of Engineers to conduct comprehensive, system-wide studies to assess the flood control and floodplain management needs in the areas that were flooded during the 1993 event. The assessment was to be accomplished over an 18-month period. A systems approach to floodplain management was to be used, recognizing and complementing the efforts of the White House Interagency Floodplain Management Review Committee.

Authorization/Objectives

The study was authorized by House Resolution 2423, dated November 3, 1993, and was a Congressional add in the Energy and Water Development Appropriations Act of 1994, which was signed into law as Public Law 103-126. This law provided the Corps of Engineers with appropriations to conduct studies in the reaches of the upper Mississippi and lower Missouri Rivers and their tributaries flooded in 1993.

The eleven objectives established for this assessment correspond to specific directives provided in the Conference Report for the above stated appropriations act (House Report 2445) and the guidance memorandum prepared by the Headquarters, U.S. Army Corps of Engineers, dated 14 December 1993. These reference documents are provided in Attachment 2 of this report.

The objectives of the assessment include the following:

a. Describe the existing land and water resources and make projections of future conditions;

b. Identify and array the desires of interested parties within the study area to reflect the diversity of opinions regarding appropriate future outputs from alternative uses of floodplain resources;

c. Describe how the array of land and water resources could be used to provide varying outputs from alternative uses of floodplain resources;

d. Describe the forces impacting on the use of identified land and water resources;

e. Develop a broad array of alternative land and water resource actions, including changes in policy, with the potential to influence the future mix of outputs;

f. Evaluate and prioritize alternative land and water resource actions based on consultation and coordination with affected Federal, State, and local entities through a series of public workshops or similar mechanisms;

g. Prepare a report to document the assessment efforts, present conclusions with regard to potential actions and alternative future floodplain uses, and recommend subsequent follow-on studies;

h. Identify critical facilities needing added flood protection;

i. Examine differences in Federal cost sharing for construction and maintenance of flood control projects on the upper and lower Mississippi River system;

j. Evaluate the cost effectiveness of alternative flood control projects; and

k. Recommend improvements to the current flood control system.

Study Area

The study area for the Floodplain Management Assessment (FPMA) includes the upper Mississippi River (from St. Paul, Minnesota, to Cairo, Illinois), the lower Missouri River (from Gavins Point Dam near Yankton, South Dakota, to St. Louis, Missouri), and major tributaries, as shown on Figure I-1. These river reaches encompass the principal areas directly affected by the 1993 flood. The assessment will focus on the floodplain of these river reaches, generally considered to be the "bluff-to-bluff" area.

Organization Structure

The North Central Division (NCD) Office had the oversight role for the assessment, and the St. Paul District was the lead District for completing the assessment. The actual work was accomplished in all five Districts (St. Paul, Rock Island, St. Louis, Kansas City, and Omaha).

Strategy

The Floodplain Management Assessment has been directed to be responsive to objectives laid out by Congress in the authorizing legislation and to complement the work that has been and is being accomplished by many others on related aspects of the floodplain issues. It is anticipated that this evaluation will be another step in achieving a better understanding of the current uses of the floodplain, forces causing those uses, and impacts of various alternative changes in the management of floodplains.

Four key reports that preceded the FPMA have been significant factors in shaping the strategy, sources of data, and direction of the conclusions reached in this report. They are briefly summarized below. Attachment 1 of this report provides a more detailed summary of each report and the addresses for obtaining copies of the four reports.

1) The **Interagency Floodplain Management Review Committee Report** of June 1994, entitled, "Sharing the Challenge: Floodplain Management in the 21st Century" (or commonly referred to as the Galloway Report).

The Interagency Floodplain Management Review Committee was established as part of the Administration's Flood Recovery Task Force. The mission of the Review Committee was to:

- Delineate the major causes and consequences of the 1993 flooding;
- Evaluate the performance of existing floodplain management and related watershed management programs; and

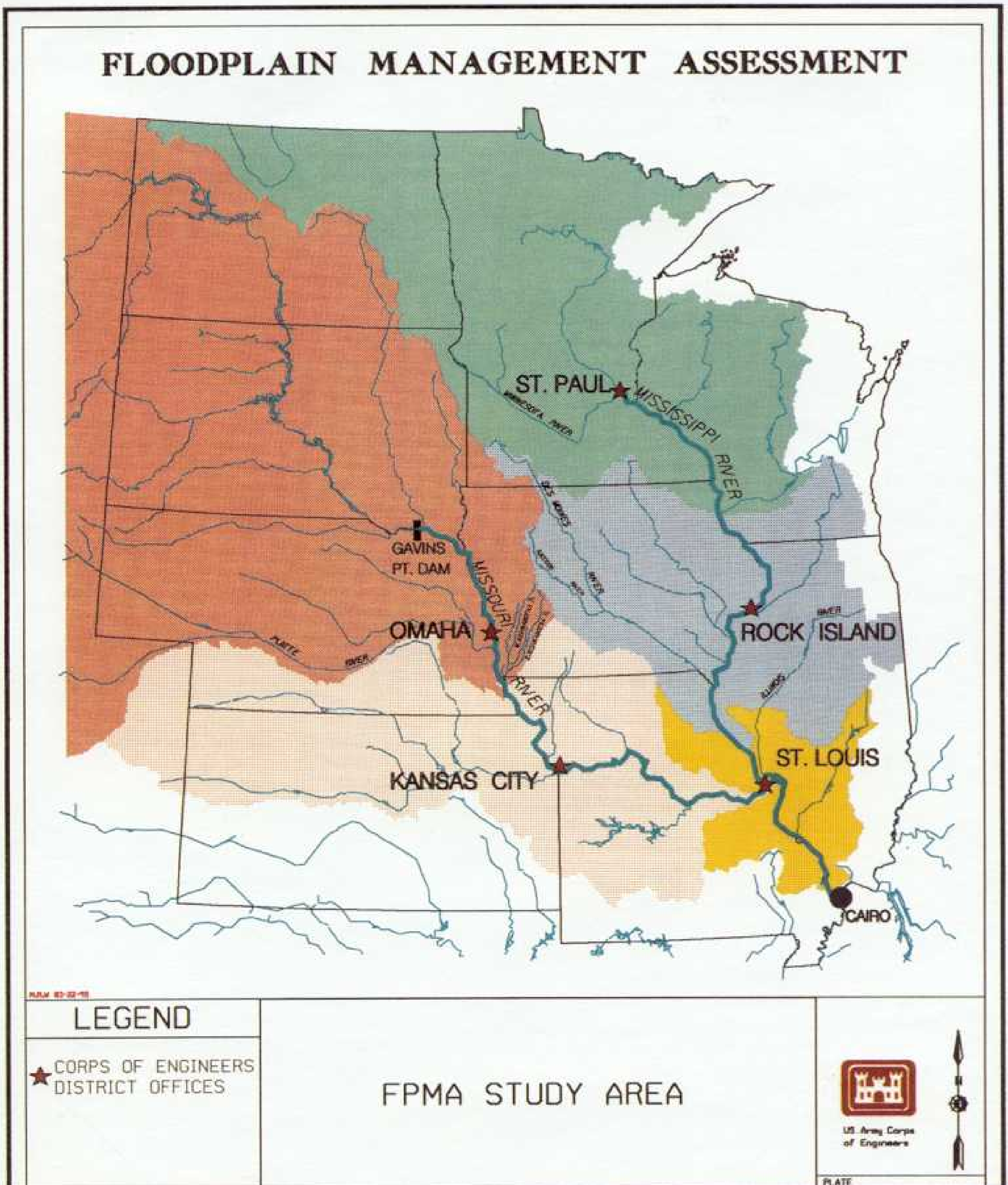

FLOODPLAIN MANAGEMENT ASSESSMENT
ST. PAUL
MISSISSIPPI RIVER
GAVINS PT. DAM
MISSOURI RIVER
OMAHA
PLATTE RIVER
ROCK ISLAND
KANSAS CITY
ST. LOUIS
CAIRO
LEGEND
CORPS OF ENGINEERS DISTRICT OFFICES
FPMA STUDY AREA
US Army Corps of Engineers
PLATE

Figure I-1

- Make recommendations to the Administration's Floodplain Management Task Force on changes in current policies, programs, and activities of the Federal Government that would most effectively achieve risk reduction, economic efficiency, and environmental enhancement in the floodplain and related watersheds.

2) The **Preliminary Report of the Scientific Assessment and Strategy Team** (SAST), which is Part V of the above report.

The SAST was chartered by the White House in November 1993 "to provide scientific advice and assistance to officials responsible for making decisions with respect to flood recovery in the upper Mississippi River Basin." It was incorporated into the Floodplain Review Committee in January 1994 to serve as its research arm for scientific analysis. The 16-member SAST team operated from the Earth Resources Observation System (EROS) center in Sioux Falls, South Dakota. Since March 1994, SAST continues to function as a distributed team with members working at their home offices or laboratories.

3) **"The Great Flood of 1993 Post-Flood Report of the Upper Mississippi River and Lower Missouri River Basins,"** which was completed in September 1994, by the U.S. Army Corps of Engineers. The five appendices were prepared by the St. Paul, Rock Island, St. Louis, Kansas City, and Omaha Districts and the main report was prepared by the North Central Division.

The Post-Flood Report was intended to document information that will be of use to professionals within and outside the Corps of Engineers in connection with future planning programs associated with reservoir water-control management, floodplain management, and emergency management. The report summarizes the meteorology of the 1993 flood event, including antecedent conditions that led to the flooding conditions. The hydrology and hydraulic parameters of this flood are compared to previous events, and there are numerous tabulations of river stages, discharges, frequencies, and flood extent mapping, as well as descriptions of the effect that levees and reservoirs had on the flood. The Corps of Engineers activities during the flood event are documented, including reservoir operations, and emergency and recovery measures. A preliminary description and appraisal of flood damages is provided.

4) The **Economic Damage Data Collection Report** of February 1995 by the U.S. Army Corps of Engineers.

The Lower Mississippi Valley Division has collected data on the impacts of the Great Flood of 1993, establishing a database containing this data, and is preparing a report entitled, "Impacts of the Great Flood of 1993, Upper Mississippi and Lower Missouri River Basins." This information quantifies the impacts of this great flood and includes maps that depict the areal extent of the flooding. The impacts are presented by county, State, and Corps District.

Another ongoing effort to assess the existing methods and procedures used by the Corps to address economic, social and environmental needs in flood management planning is being conducted by the Institute for Water Resources (IWR). A draft report entitled "An Evaluation of Corps of Engineers Flood Control Feasibility Studies for the Upper Mississippi River Basin: 1973-1994" was completed in March 1995. As with the FPMA, this report is considered to be an information document rather than a policy-setting analysis.

The objectives for the IWR report were to appraise the rationale used in decision-making in feasibility studies for flood control in the upper Mississippi River Basin. The stated need for the analysis is similar to that defined for the FPMA. It states that the economy of the upper Mississippi River Basin has grown and is expected to continue to grow. Pressures for more intensive development of the floodplains have increased over the years with the growing trend for urbanization and the scarcity of inexpensive or easily developed vacant land. The continuing trend of achieving higher uses of floodplain lands greatly increases the value of property that is susceptible to potential flooding. This increase is influenced by a growing economy and an improved level of national wealth. As a result, the potential for future damage from disasters similar to the Midwest flood of 1993 will continue to escalate unless substantive changes to current practices and policies are made.

The means of conducting the IWR analysis was to study 26 sample Corps of Engineers feasibility reports recommending flood damage reduction projects. The results of this analysis are scheduled to be available as a final draft report later this year.

The evaluations accomplished by the above efforts and other initiatives identified in this report had a significant impact on the direction and conclusions of this assessment. To best accomplish the objectives defined for this assessment while complementing the above efforts, it was decided to focus primarily on quantifying the impacts different structural and nonstructural proposals would have had if they had been in place at the time the 1993 flood event occurred. Because of the large land area involved in the study, and the many different alternatives identified by the public and others to be considered, some of the evaluations concentrated on limited reaches of the rivers, and different changes and policies and programs were combined to form three distinctive "scenarios."

Since the study encompasses floodplains along over 3,500 miles of rivers, the assessment cannot fully evaluate the array of alternatives on all reaches of the rivers subjected to flooding in 1993. Representative river reaches were used for more detailed evaluation of specific alternatives, and patterns were analyzed to determine whether application of these evaluations could reasonably be made to other similar reaches. Systemic analyses were performed only on the main stem portions of the Missouri and Mississippi Rivers, and most floodplain analyses were limited to major rivers. Therefore, the vast majority of the floodplains analyzed were wider than 0.6 mile.

The basis for estimating the effects of the various alternatives was to compare what happened in 1993 with what would have occurred in 1993 if that alternative had been in place at the time of the flooding. The analysis was not able to compare the annualized life cycle costs of alternatives with annualized flood damages to formulate any project recommendations. Instead, the analysis simply compares how implementation of various policies, programs, or flood control measures would have affected what actually occurred in the 1993 flood. Using the 1993 flood as the base condition for the comparison of impacts of various alternatives does not mean that the entire focus of the FPMA is on very large and infrequent flood events. The study area includes river reaches that experienced less than 20-year flooding. Therefore, there are opportunities to measure the change in impacts for both small and large events by recognizing the level of flooding experienced in different river reaches of the study area.

Combining a number of policy and program changes into a consistent package of measures constitutes a scenario for this assessment. Scenarios offer contrasting visions, showing where alternative floodplain management philosophies could lead. The scenarios are intended to represent a range of policies and programs, without intending to recommend a defined management plan. This framework for evaluation did not result in selection of a best plan, but rather it provides insights for future planning to properly focus on those factors with the most impact.

The policy measures comprising the scenarios involve proposals that potentially affect the ways in which exposure to flood problems can be addressed. Actions that are directed toward changing the magnitude of floods themselves, primarily through structural measures, are being modeled and addressed as part of the analysis of "action alternatives." These include alternatives involving changes to the existing network of levees.

The purpose of attempting to combine impact categories, scenarios, and action alternatives in the evaluation framework was to give substantial, consistent, and equal treatment to both "nonstructural" and "structural" alternatives as a part of this assessment. The scenarios were the mechanism that was developed to make certain that the many "nonstructural" policy and program issues of interest would be fully considered. Upon the advice of collaborating agencies, the FPMA study team concluded that a valid methodology for aggregating the impacts of scenario measures and combining them with the effects of the hydraulic action alternatives does not exist. Accordingly, the impacts of scenario measures and hydraulic action alternatives are presented separately.

Identified early in the assessment was a misconception regarding the magnitude of the flood damages. Much of the damages reported were not directly attributable to overbank flooding, but to crop damage from the excessive rains causing overly saturated soils in upland areas. Floodplain management and flood protection measures cannot reduce these damages; the best option to address these damages is a rational program of crop insurance. Therefore, an attempt has been made to separate those damages from the overbank flood damages.

The term "agricultural levee" is used extensively throughout this report. The definition provided in the glossary (Attachment 6) is "A levee that protects agricultural areas where the degree of protection is usually less than that of an urban area." It is understood that many times these agricultural levees provide flood protection for more than crops due to development behind the levees, such as residential areas, critical facilities, transportation systems, or industry. Therefore, the term "agricultural levee" is generally understood to be any levee that does not provide a high degree of protection (50- or 100-year) to predominantly urban areas. For the alternatives involving agricultural levees in this assessment, only Federal agricultural levees have been included in the hydraulic routings and impact analysis.

Hydraulic modeling has been completed for six systemic alternatives, using the 1993 flood event as the baseline condition. These include agricultural levee removals, agricultural levee raises to contain the 1993 flood event, a system of 25-year agricultural levees, a levee setback alternative, removal of reservoirs, and watershed reductions of runoff by 5 and 10 percent. Hydraulic model runs, defining expected changes in flood stages, were provided to the environmental and economic work groups for evaluation of potential impacts.

Conclusions are provided in Chapter 12 of this report. "Findings," which are greater in number, are located at the end of each chapter. These findings represent notable results from the chapter's evaluations and have been consolidated into a shorter list of conclusions for Chapter 12. The findings are also provided as a list in Attachment 9 of this report. The five appendices, which are bound separately from the main report, provide further background and supporting documentation for the assessment. Chapter 12 also provides a list of key products that have been developed or enhanced as a result of the FPMA, such as UNET modeling on the Mississippi and Missouri Rivers, digitized land use mapping, environmental resource inventory, critical facility lists and mapping, etc. These products should be thought of as tools to better reach decisions on the management of our floodplains.

Any proposed changes in Corps of Engineers budgetary constraints, cost sharing requirements, or justification of projects have not been addressed in this assessment. The primary focus instead has been on how the impacts of the 1993 flood would have varied if a range of alternative measures, policies, or programs had been in place during the Midwest Flood of 1993. This report is being distributed to the public concurrently with submittal to the Headquarters, Corps of Engineers. Subject to approval, it will be transmitted in sequence to the Acting Assistant Secretary of the Army for Civil Works, the Office of Management and Budget, and Congress.

CHAPTER 1 - FLOOD DESCRIPTION

Description of the Mississippi and Missouri River Basins

The Mississippi River rises in the lake and forest country of north-central Minnesota and flows 2,350 miles to its mouth in the Gulf of Mexico. Over this journey, it falls 1,463 feet and drains 1.25 million square miles or 41 percent of the land area of the continental United States.

That portion of the Mississippi River drainage lying above its confluence with the Ohio River at Cairo, Illinois, is commonly referred to as the upper Mississippi River Basin. (Note that for the Mississippi River itself, the reach upstream from St. Louis is called the upper Mississippi River, the reach between St. Louis and Cairo is the middle Mississippi River, and the reach downstream from Cairo is called the lower Mississippi River.) The upper Mississippi River Basin encompasses approximately 714,000 square miles, which is 57 percent of the total Mississippi River Basin and 23 percent of the land area in the continental United States. This area includes its principal tributary, the Missouri River Basin, which drains 529,000 square miles above its mouth at St. Louis, Missouri, including 9,700 square miles in Canada. The Missouri River drains 74 percent of the upper Mississippi River Basin but contributes only 42 percent of the long-term average annual flow at St. Louis.

As the Mississippi River leaves the northern woodlands and lakes above Minneapolis-St. Paul, Minnesota, it meanders southward past fertile prairies, villages, and cities. Along the way, numerous tributaries join the Mississippi River and add to its flow. The drainage area of the Mississippi River has six major subbasins: the upper Mississippi, Missouri, Ohio, Arkansas, White, and lower Mississippi. Historically, the Missouri and Arkansas Rivers have contributed greater amounts of sediment, while the Ohio River contributes the greater percentage of water discharge and the least concentration of sediment. The floodplain along the main stem of the Mississippi River varies in width from approximately three-quarters of a mile to more than 14 miles, and averages about 5 miles wide.

The Missouri River rises along the Continental Divide in the northern Rocky Mountains and flows generally easterly and southeasterly to join the Mississippi River near St. Louis, Missouri. Its drainage area includes all of Nebraska and parts of Missouri, North Dakota, Kansas, Colorado, Wyoming, Montana, South Dakota, Iowa, Minnesota, and Canada. Hydrologically, the Missouri River Basin is divided into two portions, with demarcation at Sioux City, Iowa. The upper basin contains 314,600 square miles and the lower portion contains 208,100 square miles.

Description of Flooding

The Great Flood of 1993 affected a large portion of the midwestern United States, crossing boundaries of several Corps of Engineers Districts, including: St. Paul, Rock Island, Omaha, Kansas City, and St. Louis.

The flood was unique in its areal extent as well as in its duration. It encompassed several months of relatively heavy rainfall that occurred at a time when the ambient conditions already posed a greater probability for flooding. Along the Mississippi River, many of the Federal and non-Federal levees either overtopped or were breached as a result of the record-breaking stages.

The 1993 flood was the greatest flood ever witnessed in some locations. The areal extent of the persistent rainfall and flooding was unprecedented. Over the nine-State region of the Upper Midwest, the U.S. Geological Survey (USGS)-measured discharges exceeded the 10-year event at 154 stream gaging stations, exceeded the 100-

year event at 46 stations, and exceeded the flood of record at 42 stations (some of which have more than a century of data). Flood frequencies exceeded the 500-year event at some locations along the Missouri and Mississippi Rivers, as well as some of their tributaries.

The flooding on the Mississippi River was the most devastating in terms of property damage, disrupted businesses, and personal trauma of any in the history of the United States. Millions of acres of farmland were under water for weeks during the growing season. Damaged highways and roads disrupted overland transportation throughout the flooded region. Portions of the river were closed to navigation for almost two months. The banks and channels of the Mississippi River were severely eroded in many reaches. In addition to the erosion of the river, erosion of valuable topsoil was a major problem. The extent and duration of the flooding caused numerous levees to fail.

Flood effects along the main stem of the Mississippi River were generally confined to near-bank areas and channel infrastructure from St. Paul, Minnesota, to Guttenberg, Iowa. There was no significant flooding upstream of Lock and Dam 1 in Minneapolis, Minnesota. Every gaging station on the Mississippi River below Lock and Dam 15 to Thebes, Illinois, experienced a new flood of record.

Flood conditions on the Mississippi River differed above and below the confluence of the Ohio River. At Thebes, Illinois, 46 miles upstream from the confluence, severe flooding occurred on the Mississippi River. Downstream from the confluence, flooding on the Mississippi River was not severe because of less-than-average discharge contributed by the Ohio River and a substantially larger channel capacity in this reach of the Mississippi River. The discharge of the Ohio River was less than average during July and August 1993 as a result of generally dry conditions and low reservoir outflows throughout the Ohio River.

The wet spring of 1993 resulted in the Missouri River rising above flood stage in early May and navigation being suspended from river mile 197.0 to 354.0. By May 16, the river was reopened to navigation, and the flood event was terminated on May 20. This relatively minor event set the stage for a series of events that would result in record flows and stages on the Missouri River and record pool levels at several lake projects during July and August. Portions of the Missouri River were closed to navigation in July and August 1993. Individual reaches were closed and opened during the flood based on the flow conditions in that reach. Hydrologic and hydraulic effects of excessive runoff during the summer of 1993 resulted in severe and widespread flooding throughout the lower Missouri River basin in Missouri, central and east Kansas, southeast Nebraska, and south central and southwest Iowa. Several intense storms in July, combined with wet antecedent conditions, were the principal causes of the severe flooding conditions. Record flooding inundated large areas — residential, industrial, and agricultural. The extent and duration of flooding caused levees on the Missouri River to fail or be overtopped. The Missouri River was closed to navigation for 49 days, from July 2 to August 20. Even after the record-setting flood had passed out of the Missouri River Basin, during August and September, continued rainfall caused recurrences of flooding in localized areas. Also, rainfall continued to interfere with post-flood cleanup and rehabilitation.

As a result of the flood, the Federal Emergency Management Agency (FEMA) declared 505 counties in nine States eligible for either individual or community assistance. This natural disaster killed 47 people and forced 74,000 people from their homes. It also disrupted commercial activity all along the Mississippi and Missouri Rivers and adjacent areas and destroyed thousands of acres of crops. In addition to the crop losses, many farms also lost vital structures, facilities, and equipment. The impacts of the flood are further described in Chapter 3 (Existing Floodplain Resources and Impacts of the 1993

Flood) and Chapter 5 (Establishing Base Conditions for Evaluation).

Weather Factors

Although rainfall records were not broken in the upper Mississippi River Basin in the fall of 1992, November and December had well above normal amounts. In November, rainfall totals were two to three times the normal amount. In the first seven months of 1993, more than 20 inches of rain fell over most of the flood-affected area, with more than 40 inches of rainfall occurring in areas of northeast Kansas and east-central Iowa.

Precipitation during the winter of 1992-93 and the spring of 1993 was above normal and temperatures were below normal throughout the lower Missouri River Basin. Persistent rains and early snowmelt culminated in high spring runoff. With the exception of some areas in Colorado and western Kansas, which had below normal precipitation, the period of April and May was wet and cool.

A wet-weather pattern persisted over the Upper Midwest for about 6 months. This pattern resulted from an eastward-flowing jet stream that extended from central Colorado northeastward across Kansas to northern Wisconsin. Because of this jet stream, a weather-front convergence zone formed across the Upper Midwest during the spring and summer months that preceded the flood. Moist, warm air from the Gulf of Mexico was drawn northward along this jet stream where it collided with cooler air masses drawn out of central Canada.

This combination of extreme conditions generated frequent occurrences of prolonged and excessive precipitation over the upper Mississippi River Basin, leading to the destructive floods. There has been some speculation that the 1993 floods might have been associated with greenhouse gas-induced global warming and related circulation changes. The quantitative research that has been done suggests, however, that central North America will have a drier climate as a result of global warming, although the most recent hypothesis is that highly variable and extreme conditions could result, at least initially. Thus, both extreme flood and extreme drought are consistent with the global warming theory, and the 1993 floods cannot conclusively be connected with this phenomenon.

Similarly, the volcanic eruption of Mt. Pinatubo in June 1991 has likely affected global mean temperatures, but the exact nature of the changes in circulation which might have resulted from the eruption are not known. Therefore, it is difficult to link the floods to the eruption. As with global warming, considerable study and analysis will be required before any conclusions can be drawn regarding the impact of the eruption on global circulation and specific rainfall patterns. Preliminary tests using the current El Nino Southern Oscillation (ENSO)-related sea-surface temperature anomalies in the tropical Pacific in a numerical climate model at the National Meteorological Center show a response that replicates the observed precipitation and temperature anomalies to a noticeable extent. This suggests that the current long-lived ENSO event is probably contributing to the large-scale atmospheric features associated with the floods. Similar, though less intense, features were also observed in 1992, however, with no significant flooding occurring in the areas affected in 1993. Moreover, Wayne Wendland, Illinois State Water Survey, showed that, for eight ENSO events of varying intensity since 1952, the associated mean precipitation over the upper Mississippi River Basin differed by less than 10 percent from the long-term average for the period 1961-1990. In any case, there were certainly other contributing factors to the 1993 floods. It will take more detailed analysis, involving both observations and coupled ocean/atmosphere global circulation models, to get a definitive understanding of the role of sea surface temperatures in the tropical Pacific in the recent extreme precipitation events.

Description of Storms

One of the unusual aspects of the floods of 1993 was that they were not the product of one single, large-scale event, such as an intense synoptic scale cyclone or snowmelt and runoff. The flood-producing rainfall events were typically the result of thunderstorms repeatedly forming and moving over the same area, a phenomenon sometimes referred to as the "train effect." Storms of this kind usually form right along, or just to the north or northwest of, a slow moving or stationary front aligned parallel or nearly parallel to the upper air winds. Weather disturbances moving along the surface front will cause the warmer air to the south or southeast of the front to be forced to rise over the cooler air to the north or northwest. In an area determined by the air mass and circulation characteristics, the warm air will have risen to a level where it will begin to rise freely and rapidly due to convection, generating thunderstorms which then move with the upper winds. In these situations, it is common for thunderstorms to form in and then move over the same areas, one after the other, creating the "train effect."

The alignment of the surface fronts and the jet stream during the summer of 1993 was highly favorable for the formation of the kind of weather disturbances which set off the "train effect" thunderstorms. The intensity of these storms, once they formed, was then enhanced by the extreme nature of the temperature contrasts across the region and the intensity of the jet stream.

By the summer of 1993, the mean position of the jet stream was firmly established over the northern portion of the Mississippi River basin with a southwest-northeast orientation. Major flooding began after a particularly heavy rainfall period in mid-June in southwest Minnesota and northwest Iowa. This included record flooding on the Minnesota River.

Following a short dry period, the area experienced a prolonged siege of heavy rainfall from late June extending through July 11. This included extreme precipitation on July 9 in Iowa, which resulted in record flooding on the Raccoon and Des Moines Rivers. Just as the crests from these two rivers reached Des Moines, Iowa, a relatively small, convective pocket dumped several inches of rain on the crests, rapidly boosting the river levels and flooding a water treatment plant in Des Moines. This rainfall event also led to record flooding on portions of the lower Missouri River and combined with the crest already moving down the Mississippi River, causing record river stages from the Quad Cities area, through St. Louis, and as far south as Thebes, Illinois.

Another major precipitation impulse occurred July 21 to 25. The heaviest rains were focused farther south than the earlier events, with especially heavy rain falling over eastern Nebraska and Kansas, leading to second major crests on both the Missouri and Mississippi Rivers. A third smaller crest occurred on the Missouri River in late August.

Hydrologic and Hydraulic Antecedent Conditions

There are a number of conditions which can affect runoff in a river basin and result in major flooding. The four most significant conditions relevant to the floods of the summer of 1993 in the upper Mississippi and lower Missouri River Basins were base flow, snow cover, soil moisture, and antecedent precipitation.

1. Base Flow

Along the Mississippi River from Hastings, Minnesota, to Guttenberg, Iowa, flows displayed an average fluctuation consistent with the alternating patterns of colder and milder weather. This trend was also generally observed along the Mississippi River tributaries in western and central Wisconsin, except that base flows tended to remain somewhat above average for most of the season along these tributaries. On the Minnesota River, base flows were well above the monthly averages throughout the winter.

From Lock and Dam 11 in Guttenberg, Iowa, to Lock and Dam 22 in Saverton, Missouri, streamflows were unusually high during the winter and spring of 1992-93. River flows at

Lock and Dam 11 were between 30,000 and 40,000 cubic feet per second (cfs) in January and February, compared to average flows of 25,000 cfs. Lock and Dam 22 recorded river flows greater than 60,000 cfs for most of the same time period, compared to average flows of 35,000 cfs. The Rock and Illinois Rivers, two major tributaries to the Mississippi River from the Illinois side, experienced similar unseasonably high base flows throughout the winter.

This indicates high base flow as a moderate contributing factor to the summer floods on the tributaries, and as a very significant contributing factor to the summer floods.

2. Snow Cover

Although not record breaking, the snow cover in the upper Mississippi River Basin at the beginning of the 1993 spring season was somewhat greater than normal, particularly in southern areas. Across southern Minnesota and western and central Wisconsin, snow depths at the end of February 1993 were generally in the 9- to 18-inch range with water equivalents in the 2- to 4-inch range. Frost penetration ranged from 14 inches at Lamberton to 34 inches at Morris in Minnesota, with a similar range in western and central Wisconsin. These values are not abnormal, and suggest that snow and soil conditions at the end of winter 1992-93 were not significant contributing factors to the floods of the summer 1993. Melting snow, however, did combine with above normal spring rains and below normal spring temperatures to adversely affect soil moisture conditions.

3. Soil Moisture

Soil moisture across Minnesota, Wisconsin, and Iowa in the spring of 1993 was extremely high, making this a significant contributing factor to the floods of the summer of 1993. The following shows soil moisture as a percent of capacity in four States of the nine-State area:

Minnesota	85 percent
Iowa	85 percent
Wisconsin	75 percent
Illinois	80 percent

These high values meant that a large percentage of new precipitation had nowhere to go but directly into runoff.

4. Precipitation

Precipitation patterns over Minnesota, Wisconsin, and Iowa since 1992 were a significant contributing factor to the floods of 1993. November 1992 precipitation was higher than average in all of the Midwest. Statewide precipitation records in Iowa, Minnesota, and Wisconsin were the greatest of any November since 1895. Illinois and Missouri were the second wettest. The period January through August 1993 broke many precipitation records. The first three months of 1993 generally recorded near normal precipitation. The spring of 1993 was characterized by two highly significant climatic factors: above normal precipitation and below normal temperatures.

Above normal precipitation fell in most areas in April and throughout the region in May. Nearly twice the normal precipitation fell in May. This above normal precipitation was accompanied by significantly below normal temperatures. Mean April temperature ranged from 3 to 4 degrees below normal across the entire area, with isolated stations reporting monthly averages about 7 degrees below normal. Monthly average temperatures for May were colder than normal by 1.5 to 2.5 degrees Celsius.

Rainfall for May varied from 4 inches in Missouri, Iowa, Minnesota, and southern Illinois to more than 6 inches in the western half of Iowa and extreme Missouri. This combination of precipitation and temperature had several effects. The above normal precipitation, combined with the melted winter snowpack, left soils very close to saturation. The cooler temperatures inhibited evapotranspiration, further promoting saturated soil conditions and ponding in fields. Both of these conditions delayed planting and inhibited crop root growth, which further contributed to excessive runoff.

How Well Flood Control Measures Performed

The effects of flood control structures are questioned every time a large flood occurs, and the Great Flood of 1993 proved to be no exception. Almost every night, the news media showed film of levees overtopping and rampaging floodwaters entering protected areas. Essentially, little media coverage was seen of flood control projects successfully preventing flooding. The impression on the part of the general public seemed to be: Why is a flood occurring with all the flood control structures that exist? What has gone wrong? The perception was that there had been a "failure" of flood control structures.

Contrary to popular belief, structural measures - levees, floodwalls, and reservoirs - performed extraordinarily well during the flood of 1993. All structures that were designed for an event of this magnitude prevented flooding to the areas protected by the structures. In fact, many levees designed for events less severe than the 1993 flood also stood up to this event due to heroic floodfight measures. Were it not for Federal flood control structures, an additional $19 billion in damages (based on estimates from existing damage curves) would have been experienced.

Existing reservoirs provided $11 billion in damage prevention in the 1993 flood and reduced flood stages up to 5 feet in the main stem rivers. Three major urban levees/floodwalls in the St. Louis area would have overtopped without the reservoir reductions. Six levees in Kansas City would have overtopped without the Missouri River Basin reservoirs.

Existing levees provided $8 billion in damage prevention in the 1993 flood. Damages of $4.1 billion are estimated to have been prevented by levees along the Missouri River, especially around the Kansas City metropolitan area. A significant portion of an estimated $3 billion in damages prevented around the St. Louis metropolitan area was attributable to levees. Another $1 billion or more in damages was prevented along the upper Mississippi River and tributaries in the Rock Island and St. Paul District areas.

Response and Recovery

Under Public Law 84-99, the Corps of Engineers may provide emergency assistance for flood response and post-flood response activities to save lives and protect improved property (i.e., public facilities/services and residential/commercial developments) during or following a flood. Acting for the Secretary of the Army, the Corps is also authorized to undertake activities including disaster preparedness, advance measures, emergency operations, rehabilitation of flood control works threatened or destroyed by floods, and provisions of emergency water due to contaminated sources.

District Emergency Operations Centers (EOCs) were activated, and flood area engineers were dispatched to areas to provide technical assistance which included the following:

— 24-hour-a-day service to local communities by field EOCs;
— Operation of permanent flood control projects;
— Emergency construction techniques for levee raises, closures, and sandbagging operations; and
— Monitoring flood protection works.

Corps personnel provided technical engineering support such as: mechanical and structural design assistance, hydraulic and hydrologic forecasting, and geotechnical soil stability assessments. Field personnel worked in teams of two; one member of each team was an engineer or an engineering technician.

Based upon past experience of the area flood engineers, information was provided to the communities regarding areas of potential seepage, sand boils, and erosion potential. Information regarding emergency interior drainage treatment facilities and technical assistance on filling sandbags, the proper use of polyethylene, and the sizing and placement of portable pumps was also provided to the communities.

As the flood progressed, it soon became apparent that human resources would not be enough to handle the work load. To solve this problem, the Districts involved in the flood sent out requests for personnel to other Divisions and Districts and other agencies such as the Bureau of Reclamation. In some Districts, retirees who were familiar with dams and levees were recalled to supplement the staff.

Every lock on the Mississippi River encountered a unique set of problems. Lockmasters at each lock determined what parts and equipment they would need even before the flood crest. They also determined what parts could be saved, dried, and repaired, and what equipment would be replaced. The locks were ready for operation before the Coast Guard had determined the river to be safe for traffic.

The extended spring high water and abnormal June-July flooding resulted in severe shoaling of the channel and required extensive dredging in the St. Paul and St. Louis Districts. There were several channel closures as a result of the combination of shoaling, vessel groundings, and the efforts of the vessels to get free.

Despite the critical situation for navigation, every effort was made to avoid adverse environmental impacts from dredged material placement. Nearly 80 percent of the material was placed at locations where the material was considered a beneficial use. Most of the remaining 20 percent was placed at designated temporary sites where long-term plans are to remove the material and transfer it to permanent beneficial use locations.

On the Missouri River, impacts to the navigation projects were substantial in that stone-filled dikes and revetment structures were severely damaged in at least 45 locations and will have to be repaired or replaced. The side channel areas were also severely eroded, allowing for potential channel change and shoaling conditions to develop within the channel.

Findings

1-a) The 1993 flood was the greatest flood ever witnessed in some locations. The areal extent of the persistent rainfall and flooding was unprecedented. Over the nine-State region of the Upper Midwest, the USGS-measured discharges exceeded the 10-year event at 154 stream gaging stations, exceeded the 100-year event at 46 stations, and exceeded the flood of record at 42 stations (some of which have more than a century of data). Flood frequencies exceeded the 500-year event at some locations along the Missouri and Mississippi Rivers, as well as some of their tributaries.

1-b) Existing reservoirs provided $11 billion in damage prevention in the 1993 flood and reduced flood stages up to 5 feet in the main stem rivers. Three major urban levees/floodwalls in the St. Louis area would have overtopped without the reservoir reductions. Six levees in Kansas City would have overtopped without the Missouri River Basin reservoirs.

1-c) Damages of $4.1 billion are estimated to have been prevented by levees along the Missouri River, especially around the Kansas City metropolitan area. A significant portion of an estimated $3 billion in damages prevented around the St. Louis metropolitan area was attributable to levees. Another $1 billion or more in damages was prevented along the upper Mississippi River and tributaries in the Rock Island and St. Paul District areas.

1-d) Floods greater than the 1993 flood catastrophe will happen in the future. It would be prudent to prepare for future floods larger than the 1993 event. When we are properly prepared for catastrophic flood events, smaller floods will be more easily accommodated.

CHAPTER 2 - FORCES IMPACTING USES OF THE FLOODPLAIN

Introduction

The Floodplain Management Assessment (FPMA) study has examined the forces impacting uses of the floodplain. This examination includes a **Historical Evaluation,** a statement on **Economic and Social Forces,** an **Institutional Inventory,** and a review of **Policies and Programs.** The **Historical** documentation includes a look at: (1) historical reconstruction to develop a picture of how the relatively undisturbed system functioned compared to how the system functions today; (2) historical data to document preproject channel conditions, describe channel stability/instability, and identify patterns of development; (3) riverine-riparian biodiversity in the historic floodplain; and (4) an assessment of the relative impacts of dams, diversions, levees, and other impacts. The **Economic and Social Forces** influencing uses of the floodplains are only briefly addressed in this chapter since these areas have been more extensively addressed by others in separate studies. The **Institutional Inventory** includes a compilation (list) of Federal, State and Local Agencies; Tribal Governments; Organizations and Interest Groups; Levee and Drainage Districts; Agriculture and Recreational Interests. This list is provided in Appendix D of the report. An evaluation of how these players interact, overlap, link together, or contradict purposes or goals was beyond the scope of the FPMA. The **Policies and Programs** evaluation has looked at the variations between States and local units of government; reviewed the compatibility of floodplain strategies; and looked at the effectiveness of various floodplain management approaches such as the National Flood Insurance Program. For a more in-depth analysis of the policies and programs, see Chapter 6 of this report. As we have begun to analyze these floodplain forces (Historical, Institutional, Policies and Programs), we know that: (1) the extent of damages from flooding has increased over time; (2) the responses to flooding are becoming more technical and sociopolitical; and (3) the institutional setting in relationship to flooding has become increasingly complex.

Historical Evaluation

The Upper and Middle Mississippi River History (1866-1993)

This historical overview provides a context for understanding how the middle and upper Mississippi River and the institutional arrangements for managing it had evolved by the eve of the 1993 flood. It will also help to answer questions that Congress and Corps of Engineers headquarters have asked of the study team, questions that many in the public have asked as well. These questions include: How and why have the existing land and water resources in the floodplain been used? What is the potential to rearrange current uses of the floodplain? How have various interests come to have an interest in the floodplain and how did they develop their relative strengths? How have different floodplain management and flood control practices come to be? And what role have Corps projects and policies played in shaping floodplain use and development? During and since the flood, uncounted stories have been written about it. Many of these stories have perpetuated common misconceptions about the history of floodplain development and of flood control projects and policies. Another purpose of this history, therefore, is to dispel these misconceptions. On the Mississippi River main stem, the flood of 1993 played itself out on a landscape largely established by 1940. That landscape--physical, ecological and hydraulic--was dramatically different from the one sculpted in the eons before Europeans and Americans arrived in the Mississippi River valley. The dominant player in defining the landscape was the Federal Government acting for navigation interests, floodplain farmers and conservationists.

By 1940, members of these groups had come to expect Federal aid in their efforts to use the river and its valley. With the flood control acts authorized for the upper Mississippi River between 1917 and 1938, Congress approved the first major Federal efforts to fortify the upper and middle Mississippi River's agricultural levees. After 1938, Congress and the Corps--at the insistence of floodplain occupants--expanded flood control to include urban areas, reservoir projects, and the river's tributaries. The greatest changes in the upper Mississippi River Basin after 1940 would occur in the river's tributaries and uplands. Floodplain management received little attention before 1960. After 1960, it would get greater notice, but old patterns would dominate floodplain and flood control policy up to the 1993 flood.[1]

More than any other agency, the U.S. Army Corps of Engineers has reshaped the upper and middle Mississippi River. To understand how and why the Corps first became involved with the river and how the Corps initially transformed the river's landscape, we have to examine navigation improvements. Navigation improvements have been among the most powerful influences defining the Mississippi River and its floodplains between the Ohio River and Minneapolis.

Before 1866, the river--especially above St. Louis--still possessed most of its natural character. Trees filled and enshrouded it. Hundreds of islands, some forming and others being cut away, divided it, dispersing its waters into innumerable side channels and backwaters. During high water, the river spread into its vast floodplains, filling lakes and sloughs, covering low-lying prairies, and flowing through the bottomland forests. Sandbars, hundreds in the main channel alone, segmented the natural river into a series of deep pools separated by shallows. Before the Civil War, the Corps had removed some rock from the Des Moines and Rock Island Rapids, had improved the St. Louis and Dubuque harbors, and--particularly below St. Louis--had pulled some trees from the river and had cut others from the river's banks. But, this work had been local and limited.[2]

Midwesterners and the ever increasing stream of immigrants inhabiting the Mississippi River valley demanded more extensive and systematic improvements. To them, the river was a poorly constructed highway that promised to become the region's greatest commercial artery, if properly improved. With increasing intensity from 1866 on, they sought access to the Atlantic Ocean and the world through the Mississippi River to realize their manifest destiny. That destiny, they believed, was to become a commercial and industrial power as strong as the East, as well as the Nation's breadbasket. To fulfill this destiny, they would lobby Congress to reshape the upper Mississippi River. In response, Congress has authorized four broad navigation projects for the upper Mississippi River between Minneapolis and St. Louis since 1866: the 4-, 4½-, 6- and 9-foot channel projects. Each depth was set against the low-water year of 1864. Ideally, the river would carry a 4-, 4½-, 6- or 9-foot depth if it fell as low as it did in 1864. For the Mississippi River between the Illinois River and St. Louis, Congress authorized a 6-foot channel in 1881 and that same year approved an 8-foot channel for the river between St. Louis and the Ohio River.[3]

In 1866, States along the upper and middle river convinced Congress to authorize the Corps to establish a 4-foot channel through dredging, snagging, clearing overhanging trees, and removing sunken vessels. To work on this project and on surveys of the upper river and its tributaries, the Corps established offices in St. Paul, Minnesota, and Keokuk, Iowa, in 1866. And in 1873, the Corps transferred duties for the middle Mississippi River from its Office of Western Improvements in Cincinnati to St. Louis. With the 4-foot project, and its new District offices, the Corps became the first agency to acquire a full-time management role on the upper and middle Mississippi River.[4]

Under the early improvement efforts on the middle Mississippi River and the 4-foot channel project on the upper river, the Corps began changing the river's landscape, hydraulic regime, and ecosystems. By removing snags, leaning trees, and sandbars, the Corps began--if only slightly--allowing the river to move faster down the main channel. The Corps simply did not have the equipment, personnel, or authority to make significant and lasting changes.

As the Midwest's population and agricultural production grew following the Civil War and as railroads began monopolizing bulk commodity transportation in the Midwest, pressure mounted on Congress to authorize more significant improvements. Responding to popular demand and strong lobbying by the timber industry, farmers, and upper river States, Congress authorized the 4½-foot channel project for the upper river in 1878.[5] Three years later, Congress approved a 6-foot channel for the Mississippi River between the Illinois River and St. Louis and an 8-foot channel for the river between St. Louis and the Ohio River. Under these projects, Congress directed the Corps to make the upper and middle Mississippi River into a predictable and reliable highway. This meant that the Engineers would have to create a permanent, continuous channel for the entire river between St. Paul and the Ohio River.

To achieve the 4½-, 6- and 8-foot channel depths, the Corps constricted or narrowed the main channel and cut off many of its side channels. They accomplished this by building wing dams, closing dams, and riprapping the river's banks. Long, narrow piers of rock and brush, wing dams jutted into the river from the main shoreline or from an island. Placed in a series along one or both sides of the channel, the wing dams reduced its width at low flows. Funneled between the dams, the faster moving river carried more sediment. Some of this sediment the river deposited in the calmer waters behind or between the wing dams. Within a few years, the space between the dams began filling with sand and plants. On the middle river, the Engineers used hurdles. These structures were similar to wing dams but were made by driving piles into the riverbed and weaving willow mats between them. So much silt entered the Mississippi River from the Missouri River that the willow mats filled quickly with sediment.[6]

Channel constriction demanded a strong flow of water in the main channel. During the late summer or early fall, the Mississippi River usually became a shallow, slow-moving stream. Droughts had the same effect but could last an entire season. To deliver more water to the main channel, the Engineers built closing dams. These dams ran from the shore to an island or from one island to another or across side channel openings. While the river could flow over the closing dams when high, for much of the year the dams directed water into the main channel. Despite navigation improvements made under the 4½-foot channel project, steamboat traffic on the upper Mississippi River declined; railroads still offered greater reliability and better economies of scale.

In 1902, railroad baron James J. Hill declared that shipping on the upper Mississippi River had declined so much that the river was no longer worth improving. Hill scared cities and business interests along the river and triggered the first sustained river improvement movement by Midwesterners. With a strong national interest in waterway development, a positive survey report by the Corps, and a railroad car shortage in 1906 that left grain rotting at Midwestern terminals, navigation interests pushed for and won the 6-foot channel project for the upper Mississippi River on March 2, 1907. Under this project, the Corps intensified channel constriction, further narrowing the upper river.[7] In 1927, Congress would increase the middle Mississippi River operating depth from 8 to 9 feet. Channel constriction aided by dredging would be the primary methods here as well.[8]

By 1930 the Federal Government, pushed by navigation interests, had become the most influential agency on the middle and upper

Mississippi River. Through the channel constriction projects, the Corps had transformed the Mississippi River between St. Paul and the Ohio River. In the 140-mile reach between the Twin Cities and La Crosse, they had built over 1,000 wing dams, and over 300 between St. Louis and the Ohio River.[9] But navigation supporters were not alone in transforming the Mississippi River to meet their dreams. Over the same era, floodplain farmers would greatly alter the river between Rock Island and Cape Girardeau.

Outside the navigation interests and the Corps, floodplain farmers became the primary interest actively transforming the Mississippi River and soundly establishing their stake in how it would be managed. The origin of the Mississippi River's levee system is largely a history of private development. Some farmers began building levees on the upper and middle river before the Civil War. Soon after the war, they organized into levee districts and began the first concerted effort to secure the river's floodplains for agriculture. They extended and raised levees and began draining the lands behind them. Before the Corps became involved in levee construction, these farmers had defined many of the floodplains that would be taken from the river.[10] Whereas channel constriction had altered the whole upper river, reclamation and levee building would transform the river most significantly below Rock Island.

The Corps of Engineers reluctantly entered flood control on the upper Mississippi River under its navigation improvement authority.[11] During the 1880s, individuals and organizations occupying the floodplain began pushing for Federal help.[12] As early as 1884, the Sny Island Drainage District--enclosing over 110,000 acres--south of Quincy, Illinois, asked the Federal Government to rebuild its 50-mile-long levee. The Corps reviewed the project and concluded that the levee did not help navigation and successfully recommended against Government support.[13] But the levee district persisted, and in the 1886, 1888, 1890, 1892 and 1896 Rivers and Harbors Acts, Congress authorized funding to preserve portions of the Sny Island levee in danger of eroding. The Engineers used this money to repair and riprap the levee and to build wing dams to throw the river's current away from it.[14]

Pressure also continued from other levee proponents, and in 1894, Congress instructed the Corps to survey the Mississippi River's west bank from Flint Creek, just north of Burlington, Iowa, to the Iowa River, and the river's east bank from Warsaw to Quincy, Illinois. Congress directed the Corps to determine how levees could help navigation.[15] Based on the Corps surveys, Congress, in 1895, authorized funding for both levees. In each case, the Corps was to improve navigation "by preventing the water from overflowing the natural and artificial banks along that part of the river, and deepening the channel,...."[16] The Corps completed the nearly 50-mile Warsaw to Quincy Levee in 1896 and the 35-mile Flint Creek Levee in 1900.[17]

By 1900, Congress had directed the Corps to build or protect some of the most important agricultural levees on the upper Mississippi River. In doing so, Congress avoided difficult constitutional questions about the Federal Government's role in flood protection. From its origins, the American Government had been reluctant to fund infrastructure projects because they so often benefited local or regional interests.[18] But, from the Corps' perspective, working on levees established contradictory approaches to managing the upper river. Corps engineers criticized protecting or building levees in the name of navigation because levees designed for high water flows scoured and placed sediment differently than channel constriction works designed for low flows. Considering Corps protests and questions about the Federal Government's role in flood control, Congress authorized no more levee work for the upper river until the 1917 Flood Control Act.[19]

This did not stop farmers along the river from building levees and claiming more of the river's floodplain. In 1914, the Mississippi River

Commission reported that 52 levee and drainage districts had been created between Cape Girardeau, Missouri, and Rock Island. While most of the levees were low and poorly built, they defined the first major taking of the river's floodplains.[20] The Mississippi River Commission's report came at the end of one of the strongest periods of levee district formation on the middle and upper river. Seventeen, over half, of Illinois' Mississippi River levee districts were formed between 1905 and 1916. Through their efforts, farmers below Rock Island established their stake in how the upper Mississippi River would be managed for flood control and floodplain development.

Congress had created the Mississippi River Commission in 1879 to develop plans for improving navigation, to "prevent flooding," and to generally promote commerce. Its flood prevention authority extended only to planning efforts, however. Not until the flood of 1882 did the Commission receive authority to build levees. But this authority was only for improving navigation and it applied to the river below Cairo. In the 1913 River and Harbor Act, Congress extended the Commission's authority to Rock Island.[21]

In a 1912 article on reclamation, Charles W. Durham, who had been the local engineer in charge of the Flint Creek Levee for the Corps, captured the significance of the reclamation to many Midwesterners. He asserted that:

> Aside from the pecuniary considerations, it is manifest that the conversion of a low, swampy and almost worthless tract into an aggregation of fertile farms with appropriate dwellings and farm buildings occupied by an industrious and prosperous population well provided with schools and good roads and reasonably insured against the inroad of malarious diseases, will be of great and lasting benefit to the public welfare and public health, which are important requirements of the drainage laws of the upper Mississippi valley states.[22]

Durham further contended that it had "become imperative to protect low lands from overflow by means of levees and to get rid of surface water, seepage, swamps, etc., by means of ditches and pumps,...." because good land was becoming scarce and productive lands in the floodplain had to be preserved. "Thus the matter of conservation and improvement of the soil," he declared, "has become one of the most potent questions of the day and applies with force to the valleys of the Mississippi and its tributaries."[23] Durham represented the mind-set of most Americans during this era--the same mind-set underlying the push for the river's development as a navigation corridor. Under this mind-set, failing to use the Nation's bountiful natural resources was wasteful.[24]

Responding in part to States along the Mississippi River, Congress passed an official flood control act in 1917.[25] The country's first flood control act, it allowed the Corps to work on levees from the Head of Passes in Louisiana to Rock Island and on the Sacramento River, in California.[26] This act, more so than the 1936 Flood Control Act, marks the formal beginning of the Corps involvement in flood control on the upper and middle Mississippi River. Through this act, the Federal Government assumed an official role in securing the Mississippi River's floodplains for agriculture and gave the Corps a new mission for managing the middle and upper Mississippi River, a mission Congress strengthened in the 1928 Flood Control Act.[27] Under these two acts, the Corps helped fortify levees in 11 levee and drainage districts that enclosed over 260,000 acres of floodplain.[28]

Then, in 1936, Congress passed the first national flood control act. Along with the 1938 Flood Control Act, this act broadened the Corps' role in flood control on the Mississippi River. These acts provided for flood control reservoirs, urban or local flood protection projects, and floodplain management. For the middle and upper river's main stem, however, the acts focused on agricultural levees. Under the 1936 Flood Control Act, Congress authorized 26 projects for the Mississippi River's main stem above the Ohio River. Of these, 25 called for raising and enlarging existing levees protecting agricultural lands. Only the East St. Louis and Vicinity project was authorized to protect an urban area.[29] Congress extended its protection of the main stem's agricultural levees in the 1938 Flood Control Act. The five levee improvement projects authorized in this act were to protect existing levee and drainage districts in Illinois between Alton and the mouth of the Ohio River. Together with the agricultural levee improvements authorized under the 1936 act, these projects fortified most of the levee system on the Mississippi River in Missouri and Illinois. And as the Corps had reinforced the levee system above Alton under the acts preceding 1936, the Corps had helped secure most of the important agricultural levees between Rock Island and the Ohio River.

Congress extended the Corps' flood control work to the middle and upper river's tributaries in the 1936 act. Congress had authorized improvement of many of the Illinois River's agricultural levees in the 1928 act, but little work had been approved for other tributaries. In 1936, Congress authorized 15 projects for the Illinois River, 14 for agricultural levee and drainage districts and one for a levee setback and floodway improvement.[30] Demonstrating its willingness to consider non-levee projects, Congress authorized four flood control reservoirs for the main stem's tributaries in the 1936 act and another in the 1938 act. In 1936, it provided for dams and reservoirs at Decorah, Iowa, on the Upper Iowa River, and for the Des Moines River about 60 miles below Des Moines (Red Rock project). For Illinois, Congress approved the Carlyle dam and reservoir on the Kaskaskia River, and for Minnesota, it approved the Lac qui Parle dam and reservoir on the upper Minnesota River. The Decorah, Carlyle, and Red Rock projects were specifically aimed at protecting urban populations, although they guarded agricultural lands as well. The Lac qui Parle project had the more general objective of safeguarding the Minnesota River valley downstream.[31] In 1938, Congress authorized the Coralville dam and reservoir, on the Iowa River, to protect Iowa City and some 1,073 square miles downstream.[32] With these projects, Congress had authorized four of the major reservoirs that would be built on the upper Mississippi River's tributaries above the Missouri River's mouth (Decorah would become a diversion project).

In the acts passed between 1886 and 1938, Congress established the Federal Government's role in protecting property and people in the upper and middle Mississippi River valley from floods. It instilled the expectation that the Federal Government would do so. Through these acts, Congress endorsed and encouraged floodplain development for agriculture. And the acts solidly anchored the Corps' and Congress' reliance on levees and other structural measures. When added to the navigation improvement mission, the flood control responsibility extended and deepened the Corps' management role on the Mississippi River.

Combined with channel constriction, reclamation had transformed the landscape, environment and hydraulic character of the Mississippi River between Rock Island and the Ohio River. Whereas moderate floods above Rock Island could still spread over most of the natural floodplain, only larger floods could do so below Rock Island. Here the river was now constricted at both high and low water.

By the 1920s, some conservationists argued that reclamation, channel constriction, pollution, siltation, and overuse threatened to overwhelm the river's fish and wildlife. Consequently, they initiated two efforts to reserve and develop large parts of the upper Mississippi River for native plants and animals and for recreation.[33] First, they tried to establish a national park, and second, they sought to create a national wildlife and fish refuge. Through these two movements, conservationists more clearly defined their visions for the river and organized to achieve those visions. Proposed in the early 1900s, the park movement gained strength after 1916. By 1921, however, it had stalled and conservationists started a new movement.

In 1922, Will Dilg--the Izaak Walton League's co-founder--suggested that Congress create a 260-mile-long national fish and wildlife refuge between Wabasha, Minnesota, and Rock Island. To convince Congress to act quickly and positively, refuge proponents argued that the upper Mississippi River valley faced an environmental crisis. If Congress did not create the refuge immediately, the Nation would lose one of its greatest fish and wildlife reserves, important commercial food and fur resources, the best recreation area in the central United States, and spectacular scenery. To bolster their arguments, they secured experts and concerned citizen groups from around the country to testify for the bill. H.C. Oberholser, speaking for the Biological Survey, asserted that "we must, if we are to keep up the supply of our wild life, do something before it is too late; and it is rapidly becoming too late."[34]

Under Dilg's leadership, conservationists used the draining of floodplain wetlands to push for the refuge. In 1923, landowners in an area called Winneshiek Bottoms proposed to drain much of this 30-mile-long wetland for agricultural use. The bottoms comprised an area of about 13,000 acres below Lansing, Iowa, on the Wisconsin shore and about 15,000 acres above Lansing on the Iowa side. This project showed that farmers above Rock Island were beginning to think about using the river's floodplain wetlands.[35]

Responding to pleas by conservationists and to national support for the refuge, Congress passed the refuge bill, and President Calvin Coolidge signed it on June 7, 1924, creating the Upper Mississippi River Wildlife and Fish Refuge. Congress appropriated $1.5 million for purchasing land between Rock Island and Wabasha, and by 1929, the Federal Government had bought over 100,000 acres for the refuge, which would eventually include 195,000 acres.[36] The refuge further defined the upper Mississippi River's landscape by removing much of this land from potential reclamation.

Just as conservationists won the refuge, navigation on the upper river died. By 1918, virtually no through traffic moved between St. Paul and St. Louis. As the region's need for a diverse transportation system had grown, its shipping options had declined, creating a transportation crisis. Railroad car shortages, the Panama Canal's opening in 1914, several Interstate Commerce Commission decisions, and the failure of channel constriction to restore river traffic erected, some Midwesterners declared, an "economic barrier" around their region. Although the Engineers had built thousands of wing dams and had closed many of the river's side channels, they had been unable to create a dependable navigation channel. All too frequently, droughts and floods made the channel impassable. Rail car shortages, occurring in 1906-1907, during World War I, and in 1921, caused acute, short-term shipping crises, and pointed out the Midwest's dependence on railroads.[37] The Panama Canal's opening in 1914 redefined the Midwest's transportation problems. While railroad car shortages had been infrequent, the Panama Canal created a problem that promised to become steadily worse. Economically, the Panama Canal moved the East and West coasts closer to each other while moving the Midwest farther away from both coasts. Businesses could ship goods from New York to San Francisco through the Panama Canal cheaper than Midwesterners could ship goods to either coast by rail.[38]

In response, Midwestern business and navigation interests initiated another movement to revive navigation, a movement that surpassed all previous movements. Between 1925 and 1930, they fought to restore commerce and to persuade Congress to authorize a new project for the river, one that would allow the river to truly compete with railroads. It would draw support from the largest and smallest businesses in the valley, from most of its cities, from the Midwest's principal farm organizations, and from the major political parties. Responding to this movement, Congress included the 9-foot channel project in the 1930 Rivers and Harbors Act.[39]

With the 9-foot channel project, Congress authorized a new approach to navigation improvement on the upper Mississippi River. Rather than narrowing the river and depending solely on the flow of water from the basin, Congress approved 23 locks and dams to store water in reservoirs or pools. Only in this way, the Engineers insisted, could they guarantee a 9-foot channel.

Placing locks and dams in the river was not a new idea. During the second decade of the 20th century, navigation and hydroelectric power backers joined to build two structures. In 1913, the Keokuk and Hamilton Power Company completed a hydroelectric power plant and a lock and dam at Keokuk, Iowa. While the reservoir created by the new dam flooded the Corps' canal bypassing the Des Moines Rapids, it provided a deep channel for 41 miles upstream from the dam. The project also helped floodplain farmers. The hydroelectricity produced by the new plant allowed drainage districts to employ electric pumps to more quickly and thoroughly drain their lands.[40] And the Keokuk and Hamilton Power Company paid for the entire lock and dam project.

Hydroelectric power supporters did not initiate the building of a lock and dam in the Twin Cities but they did define how the Corps built the project. In 1894, after decades of lobbying, navigation advocates in Minneapolis finally convinced Congress to build two low locks and dams to make their city the head of navigation on the Mississippi River. While the project was underway, hydroelectric power came of age and its proponents in the Twin Cities began lobbying for a new project that called for one high dam. In the 1910 River and Harbor Act, Congress granted their wish. After revamping the project by removing the original Lock and Dam 2, which had been completed in 1907, and rebuilding Lock 1 to the new height, the Corps completed the project in 1917. It included the base for a hydroelectric power plant, on which the Ford Motor Company would open its station in 1924.[41]

By 1925, the Corps had learned that it could not achieve a 6-foot channel between Hastings, Minnesota, and St. Paul without a lock and dam. Pushed by navigation interests, "who advanced money for the preliminary surveys, borings and initial design work," Congress authorized Lock and Dam 2 for Hastings in the 1927 Rivers and Harbors Act and the St. Paul District completed the project in 1930.[42] So by the eve of the 9-foot channel project, three dams were in place on the upper Mississippi River. Through the Keokuk and Lock and Dam 1 projects, hydroelectric power interests had gained a stake in how the river would be managed. Through all three projects, the precedent for navigation dams had been established.

To create a 9-foot channel, the Corps chose locks and dams and quickly determined that the dams would have to be quite low. Numerous villages and cities rested just above ordinary high water. Railroads following the river on each bank were often just out of reach of high water. At larger river cities, industrial developments lined the stream closely. Because of the small difference between the natural high water mark and the elevation of railroads, buildings, and other structures along the river and because of the small range of the annual flood stages, the Engineers concluded that the dams would have to be designed not to increase flood stages.[43] While they expected that contracting the river near the dams would increase the flood height at the dams by 1 foot, they had calculated that this effect would dissipate within a few miles above the dam. Given the location of dams, the Engineers expected no adverse effects from flooding by this effect.[44]

Another constraint determined the height of the dams. For a large part of the river below Rock Island, the report noted, one or the other of the banks, and in some cases both banks, were lined by levees. These levees made any considerable raising of the permanent low-water elevation a problem. Raising the river too much would leave parts of some levees wet all year that had previously been wet only at high and medium river stages. Being wet all the time would greatly weaken the levees. High dams, the Engineers therefore determined, were not possible. Heeding pressure from the conservationists, the Engineers also noted that low dams would not seriously flood the Upper Mississippi River Wildlife and Fish Refuge.[45]

In 1940, the Corps completed the 9-foot channel project. Twenty-six locks and dams now crossed the river between Minneapolis and Alton. (Lower and Upper St. Anthony Falls Locks and Dams would be completed in 1956 and 1963, respectively. Lock and Dam 27 would be finished in 1964, bringing the total to 29.) The 9-foot channel project again reconfigured the upper Mississippi River's landscape, hydraulic character, and environment. The pools created by the dams permanently flooded thousands of acres that had been seasonally flooded before. Because the Engineers took damage to cities, towns, and villages into consideration in planning the location of the dams, few of them would require special protection. The greatest flowage effects would occur to agricultural lands, floodplain forests, and brushlands.

The middle Mississippi River also experienced a surge of work after 1930. Frederick J. Dobney, author of the St. Louis District history, reports that between 1930 and 1945, the District spent more on navigation improvements for the middle river than they had up to 1930. During this era, they built 768 dikes or hurdles, totaling 404,000 linear feet, and 224 revetments or bank protection projects, totaling 276,000 linear feet.[46]

The upper and middle Mississippi River's landscape as it existed on the eve of the 1993 flood had, for the most part, been shaped by 1940. Urban projects had yet to be built, but these would represent minor changes in the river's floodplains compared to what had been done. Above Rock Island, where farmers had constructed few levees, the 9-foot channel reservoirs returned the braided channels and overflowed floodplains. Between Rock Island and Alton, Illinois, the agricultural levees prevented the reservoirs from spreading out as much. Below Lock and Dam 26, Congress had provided for a 9-foot channel through dredging and continued channel constriction.

In 1940, navigation was still the primary use and the Corps the dominant agency. But other interests had staked their claims. Farmers had convinced the Federal Government to reinforce their investment in the river's floodplains. Hydroelectric power interests had acquired important points on the river, inundating the valley behind their dams to a level anticipating the 9-foot channel locks and dams. Conservationists had won the Upper Mississippi River National Wildlife and Fish Refuge, and compromises made under the 9-foot channel project signaled a new framework for managing the upper Mississippi River.

What role the Government should play in protecting floodplain occupants had also been established. People expected the Federal Government to defend them and their property, largely at Federal expense. For the upper Mississippi River valley, this pertained mostly to the agricultural population. But some people began questioning this paradigm. In 1936, Harlan Barrows and his student, Gilbert White, both suggested alternatives to the structural approach. In May 1936, on the eve of the Government's entry into the national flood protection arena, Gilbert White, who would become one of the leading national experts on floodplain management, suggested that land use planning might be an effective alternative to reducing flood damage. He argued that relocating structures and modifying farming practices in some floodplains might save more money than structural flood control measures could, a position he articulated in his 1942 doctoral dissertation entitled *Human Adjustment to Floods*.[47] Then, in a report to President Franklin Roosevelt in late 1936, the Water Resources Committee of the National Resources Board, which Barrows chaired, suggested that preventing floodplain growth should be tried where it would be cheaper than building a flood storage dam. "For the first time," Corps senior historian Martin Reuss observes, "an official government document recommended something other than building dams, floodwalls, and levees to protect life and property."[48] But Congress and the Corps disagreed.[49] **Few Americans were ready to consider floodplain regulation--restricting floodplain use--until they perceived that structural solutions had failed or until enough Americans began viewing floodplains as more than untapped agricultural lands.**

Finally, the power structure, the role of various stakeholders, had been well grounded. The Federal Government's hand was dominant throughout. At the request of navigation interests and floodplain farmers and through the Corps of Engineers, the Government had transformed the river for navigation and floodplain development. For conservationists and through the precursors of the Fish and Wildlife Service, it had carved out a large part of the upper Mississippi River valley for a fish and wildlife refuge, which it managed. As of 1940, navigation interests, farmers, and others who sought to develop the river's floodplains clearly dominated and would for many more years.

World War II interrupted flood protection work on the middle and upper Mississippi River. But even before the war's end, Congress and the Corps had returned to building the Nation's flood protection infrastructure, and they continued their focus on structural projects. While the Corps was building the agricultural levees authorized in the 1936 and 1938 Flood Control Acts, Congress shifted its attention to urban projects on the Mississippi River and its tributaries. Following the 1938 act and up to the 1954 act, Congress authorized work for only two main stem agricultural levee districts--Prairie du Rocher and Sny Island--both in the 1946 Flood Control Act.[50] In 1946, Congress also approved the Illinois River Flood Control Project, an unusual project in that it called for reclaiming a levee district from agriculture.[51]

Urban levees were the principal focus, however. In 1944, Congress enacted local projects for Sabula, Des Moines, and Elkport, Iowa, and Galena, Illinois. Only Sabula lay on the main stem.[52] In the 1948 Flood Control Act, Congress authorized no projects for the Mississippi River below the Twin Cities. It did approve a channel diversion project to protect Aitkin, Minnesota, on the Mississippi River north of Minneapolis, a project to defend South Beloit on the Rock River in Illinois (now deauthorized), and a project to protect agricultural bottomlands along the Henderson River.[53] In Section 205 of the 1948 act, Congress gave the Secretary of the Army the power to approve flood protection works under $2 million (today this limit is $5 million). Although the Corps has built many projects under this authority, these projects have not been examined in this discussion. In the 1950 Flood Control Act, Congress again focused on urban flood protection, authorizing projects for Canton and Cape Girardeau, Missouri, on the Mississippi River, and another urban project for Beardstown, on a small tributary of the Illinois River.[54] In neither act did Congress authorize agricultural projects for the main stem and only the Henderson River agricultural project for the upper river's tributaries.

Congress returned to the Mississippi River's agricultural levees in the 1954 Flood Control Act. Up to 1936, Congress had concentrated on the agricultural levees between Rock Island and Alton. In the 1936, 1938, and 1946 Flood Control Acts, it had authorized the Corps to reinforce the levee system below Alton. With the 1954 act, it came back to modernize the reach between Rock Island and Alton. Under this act, Congress called for the modification or construction of 14 rural levee projects within the

Rock Island District. Between Rock Island and Hamburg, Illinois, this act called for improving 335 miles of levee "to protect agricultural land along both sides of [a] 200-mile stretch of the Mississippi River."[55] Adding the Sny Island Levee and Drainage District to this, which had been approved by this act and lay in the St. Louis District, increased the total miles of levee improvement to 386.[56] The act also included the Upper Iowa River project near New Albin, Iowa, which entailed improving the outlet of the river at its confluence with the Mississippi River to protect agricultural lands. Through this act, as they had done under the others, farmers strengthened their hold on the upper Mississippi River's floodplains.

Urban projects received attention as well. The 1954 act included projects for four urban areas: Alton, Illinois; Hannibal, Missouri; and Sabula and Muscatine, Iowa. Although Muscatine and Hannibal lay on the Mississippi River, the projects at these cities were to protect them from flooding on tributary rivers.[57] As in 1950, the 1954 act authorized no work on agricultural levees on the upper Mississippi River's tributaries; nor did it approve any urban levees for cities on tributaries off the Mississippi River.

With the most important agricultural levees on the upper and middle Mississippi River being secured, Congress concentrated on urban levees and broad flood protection on the Mississippi River tributaries in the 1958 Flood Control Act. In it, Congress approved four projects for Minnesota: the Winona and St. Paul-South St. Paul projects on the Mississippi River, the Mankato-North Mankato project on the Minnesota River, and the Rushford project on the Root River. Rather than a levee, Congress authorized a large earthen dam to protect the small town of Spring Valley, Wisconsin, on the Eau Galle River. The largest project under the 1958 Act was the Saylorville dam and reservoir on the Des Moines River, about 11 miles above the city of Des Moines. Congress authorized this reservoir to supplement the flood storage capacity of the Red Rock reservoir to reduce the flood levels downstream on the Des Moines River, especially at Des Moines, and to lower flood levels on the Mississippi River.[58]

The 1958 act also called for two extensive projects for tributaries in Illinois. On the Rock and Green Rivers, which flow into the Mississippi River near Rock Island, Congress approved a long levee project protecting mostly agricultural lands and some small towns, roads, and railroads (this project was never built and is now listed as inactive). On the Kaskaskia River, which flows into the Mississippi River near Prairie du Rocher, Illinois, Congress approved the construction of levees to protect agricultural lands and the building of two dams: Carlyle (which had been authorized in 1938) and Shelbyville.[59]

Building on the heritage of agricultural levee protection and responding to growing urban populations, Congress and the Corps expanded the flood protection program to include urban levees, reservoirs, and diversion projects between 1944 and 1958. But only once these projects and those authorized earlier had been built would the flood protection infrastructure of the upper and middle Mississippi River and its basin take shape. Projects completed by the Corps up to 1960 were largely done so under acts authorized before 1940. Prior to 1950, the Corps had completed 18 agricultural protection projects for the main stem and no urban projects. By 1960, the number of completed agricultural projects had grown to 31, but only 3 urban projects had been completed on the upper river. Of these, only Sabula, Iowa, was on the upper Mississippi River proper. Aitkin, Minnesota, rests on the Mississippi River about 130 miles north of St. Paul, and Galena is a few miles off the main stem on the Galena River. Clearly, urban flood control on the main stem was in its infancy as of 1960. (Table 2.1)

Table 2.1
Upper and Middle Mississippi River
Mainstem
Flood Control Projects
Project Type, Authorization Date and Completion Date
1884-1995

PROJECT NAME	NATURE	AUTHORIZED	COMPLETED
Warsaw to Quincy (Hunt, Lima Lake & Indian Grave)	Ag.	1895	1896
Flint Creek to Iowa River	Ag.	1895	1900
Sny Island Levee and Drainage District	Ag.	1884,86,88,90,92,96	By 1900
Drury Drainage District	Ag.	1917	1920
Bay Island Drainage & Levee District No.1	Ag.	1917	1922
Hunt Drainage District	Ag.	1917	1922
Lima Lake Drainage District	Ag.	1917	1922
Henderson County Drainage District No. 3	Ag.	1917	1925
Henderson County Drainage District No. 1	Ag.	1928	1929
Lima Lake DD	Ag.	1928	1930
Henderson County Drainage District No. 2	Ag.	1928	About 1930
Indian Grave Drainage District	Ag.	1928	1932
Bay Island D&LD No. 1	Ag.	1928	1933
Marion County Drainage District	Ag.	1928	1933
South Quincy Drainage & Levee District	Ag.	1936	1939
Fabius River Drainage District	Ag.	1936	1941
Kaskaskia Island Drainage & Levee District	Ag.	1938	1943
Henderson Co. DD No. 3	Ag.	1936	1948
Galena, Galena River	Urban	1944	1951
East Cape Girardeau & Clear Creek Drainage District	Ag.	1936	1953
Chouteau, Nameoki & Venice D&L District	Ag.	1936	1955
Miller Pond Drainage District	Ag.	1938	1955
Aitkin, Minn.	Urban	1948	1957
Sabula, Iowa	Urban	1954	1957
Harrisonville & Ivy Landing Drainage & Levee District No. 2	Ag.	1936	1957
Stringtown - Fort Chartres & Ivy Landing	Ag.	1938	1957
North Alexander Drainage & Levee District	Ag.	1936	1957
Fort Chartres & Ivy Landing	Ag.	1936	1958
Preston Drainage & Levee District	Ag.	1936	1959
Degognia & Fountain Bluff Drainage &Levee District	Ag.	1936	1959
Prairie du Rocher & Vicinity	Ag.	1946	1959
Upper Iowa River	Ag.	1954	1959
Grand Tower D&L District	Ag.	1938	1959
Columbia Drainage & Levee District	Ag.	1936	1959
Muscatine, Mad Creek	Urban	1954	1960
Clear Creek D&L District	Ag.	1936	1962
Prairie du Pont Levee & Sanitary District	Ag.	1936	1962
Hannibal, Bear Creek	Urban	1954	1962
Drury DD	Ag.	1954	1963
Fabius River DD	Ag.	1954	1963
Canton, Missouri	Urban	1950	1964
Cape Girardeau, Missouri	Urban	1950	1964
Des Moines & Mississippi Levee Dist #1	Ag.	1954	1966
South River Drainage District	Ag.	1954	1966
Bay Island D&LD No. 1	Ag.	1954	1966
Green Bay Levee & Drainage District	Ag.	1954	1966
Subdistrict No. 1, Drainage Union No. 1 & Bay Island	Ag.	1954	1967
Marion Co. DD	Ag.	1954	1967

Table 2.1
Upper and Middle Mississippi River
Mainstem
Flood Control Projects
Project Type, Authorization Date and Completion Date
1884-1995

Henderson Co. DD NO. 2	Ag.	1954	1967
So. Quincy D&LD	Ag.	1954	1967
Winona, Minn.	Urban	1958	1967
St. Paul & So. St. Paul, Minn.	Urban	1958	1968
Perry County D & LD Nos. 1, 2 & 3	Ag.	1936	1968
Henderson Co. DD No. 1	Ag.	1954	1968
Muscatine Island Levee District &	Ag.		
Muscatine - Louisa Cty Drainage Ditch		1954	1969
Prairie du Pont L&SD	Ag.,	1962	1970
Indian Grave DD	Ag.	1954	1971
Sny Basin	Ag.	1946	1971
Gregory Drainage District	Ag.	1962	1971
Iowa River - Flint Creek Dis. No. 16	Ag.	1954	1971
Hunt & Lima Lake Drainage District	Ag.	1954	1972
Dubuque, Iowa	Urban	1962	1973
Guttenberg, Iowa	Urban	1962	1973
Rock Island, Illinois	Urban	1962	1974
Wood River Drainage & Levee District	Ag.	1965	1977
Meredosia Levee & Drainage District	Ag.	1948	1977
Columbia D&LD	Ag.	1962	1978
St. Louis and Vicinity, Missouri	Urban	1955	FY 1980
Bettendorf, Iowa	Urban	1968	1981
Clinton, Iowa	Urban	1968	1981
Prairie du Chien, Wisconsin	Urban	1974	1984
East Moline, Illinois	Urban	1968	1984
Fulton, Illinois	Urban	1968	1984
Mississippi River Agricultural Areas (Area 8)	Ag.	1966	1986
Wood River Drainage & Levee District	Ag.	1938	1988
East St. Louis and Vicinity, Illinois	Ag. & Urb	1965	1990
Hannibal, Missouri	Urban	1962	[1992]
State Road & Ebner Coulee, (LaCrosse, Wisconsin)	Urban	1968	1993
Bassett Creek (Minneapolis, Minnesota)	Urban	1976	[1995]
East St. Louis and Vicinity, Illinois	Urban	1988	[1995]
St Paul, Minnesota	Urban	1986	1995
Cape Girardeau - Jackson Metropolitan Area - Missouri	Urban	1986	Underway
Perry Co. D&LD 1, 2, 3	Ag.	1972	Underway
St. Genevieve, Missouri	Urban	1986	Underway
Muscatine Is. LD & Muscatine-Louisa Cty DD	Ag.	1986	Awaiting Funding
East St. Louis and Vicinity, Illinois	Ag. & Urb	1936	?
Kaskaskia Is. D&LD	Ag.	1962	?

The pattern on the upper river's tributaries is similar. After authorizing nearly 40 projects to protect agricultural lands on the upper Mississippi River's tributaries north of the Missouri River in the 1928, 1936, and 1938 Flood Control Acts, Congress authorized only 4 agricultural projects between 1940 and 1960 (Table 2.2). Prior to 1950, the Corps had completed 25 agricultural projects and 2 urban projects on the Mississippi River tributaries. Congress had authorized one of the urban projects, Mill Creek and South Slough at Milan, Illinois, in 1927 in compensation for a navigation project that had eliminated the outlet of Mill Creek to the Rock River. The Engineers completed this project, their first urban project in the upper Mississippi River Basin, in 1932. The other project was a small one at Elkport, Iowa. Three other projects finished before 1950 were designed to protect both agricultural lands and urban areas.

Between 1950 and 1960, the Corps completed three additional agricultural projects and no urban levee projects on the upper and middle Mississippi River tributaries. The most important projects of this decade were the first two reservoirs for the upper Mississippi River: Lac qui Parle on the upper Minnesota River and Coralville on the Iowa River.[60] Lac qui Parle, completed in 1951, had the general purpose of protecting lands downstream. The Coralville project, completed in 1958 and located just upstream of Iowa City, specifically protects urban and agricultural lands and helps reduce flood heights on the Mississippi River downstream of the Iowa River's mouth. By 1950, then, the agricultural levee construction phase for the upper Mississippi River tributaries was largely over. A new phase of urban projects and multiple-purpose reservoirs was just beginning. As on the main stem, very little of the urban flood protection infrastructure on the upper and middle river's tributaries was in place as of 1960, and the focus was entirely structural.

As the concept of floodplain management enters the picture, it is necessary to define its relationship to other terms used for flood damage reduction. Floodplain management and structural flood protection are not opposing concepts. Structural flood protection is one method for limiting flood damage. Floodplain regulation--limiting and defining what development can occur in a floodplain--is another. Floodplain management can easily be confused with floodplain regulation. The Galloway Report defines floodplain management as "The operation of an overall program of corrective or preventative measures for reducing flood damage, including but not limited to watershed management, emergency preparedness plans, flood control works, and floodplain management regulations."[61]

Floodplain regulation had gained little attention before 1960.[62] Americans believed that structural projects could eliminate flooding, and that floodplain land in the valleys of the main stem and its tributaries was best used for agricultural or urban development. Not until enough projects had been built and tested could Americans begin to reevaluate these beliefs. This would not occur in the upper and middle Mississippi River basin until after 1960. Although the frequency of flood damages in protected areas fell, flood damages continued in unprotected areas, and Americans questioned floodplain use more strenuously after 1960. Any effort to manage the Mississippi River's floodplains to minimize flood damage by limiting development or removing development would have to confront the long history that had encouraged floodplain use.

The Corps had considered floodplain occupation as a principal cause of flood-related damages as early as 1913. After the 1913 flood on the Ohio River killed 415 people and caused $200 million in damages, President Woodrow Wilson created a Board of Officers on River Floods to review the country's flood problem.

Table 2.2
Upper and Middle Mississippi River Tributaries
Flood Control Projects
Project Type, Authorization Date and Completion Date
1927-1995

Nutwood Drainage & Levee District	Ag.	1928	1932
Mill Creek & South Slough at Milan	Urban	R&H Act 1927	1932
Keach Drainage & Levee District	Ag.	1928	1933
Scott County Drainage & Levee Dist	Ag.	1928	1933
Hartwell Drainage & Levee District	Ag.	1928	1933
Big Swan Drainage & Levee Dist	Ag.	1928	1934
Hillview Drainage & Levee District	Ag.	1928	1934
Mauvaise Terre Drainage, Dis	Ag.	1928	1936
Lost Creek Drainage & Levee Dist	Ag.	1936	1937
Coon Run Drainage & Levee Dist	Ag.	1928	1938
Seahorn Drainage & Levee District	Ag.	1936	1939
Oakford Special Drainage District	Ag.	1936	1939
Mason & Menard Drainage Dist	Ag.	1936	1939
Rocky - Ford Drainage & Levee Dist	Ag.	1936	1940
Hennepin Drainage & Levee District	Ag.	1936	1940
New Pankeys Pond, Special Drainage Dis	Ag.	1928	1940
Sangamon River near Springfield	??	1936	1940
Penny Slough Drainage & Levee Dist	Ag.	1936	1940
Spring Lake Drainage & Levee Dist	Ag. & Urban	1936	1941
Farmer's D & L Dist, Sangamon R	Ag.	1936	1941
South Beardstown & Valley D&L Dist	Ag.	1928, 36 & 38	1941
Crane Creek Drainage & Levee Dist	Ag.	1938	1941
Liverpool Drainage & Levee District	Ag. & Urban	1936	1941
East Liverpool Drainage & Levee D	Ag.	1936	1941
Banner Special D & L Dist	Ag.	1936	1941
Big Lake Drainage & Levee District	Ag.	1938	1943
Meredosia Lake & Willow Creek Drainage & Levee Dis	Ag.	1938	1944
East Peoria Drainage & Levee Dist	Ag.	1936	1945
Turkey River Elkport	Urban	1944	1949
Kerton Valley Drainage & Levee Dist	Ag.	1936	1949
Remedial Work - Mouth of Sangamon River	Ag. & Urb	1936	1949
Lac qui Parie Reservoir	Gen. FC	1936	1951
Coal Creek Drainage & Levee Dist	Ag.	1938	1954
Pekin & La Marsh Drainage & Levee	Ag.	1936	1954
Farm Creek	Urban	1944	1954
Coralville Lake, Iowa River	MP	1938	1958
Dry Run, Upper Iowa River	Ag.	1936	1960
Devil's Kitchen Dam, Grassy Creek	MP	1955	1960
Marshall	Urban	1960	1963
Carlyle Lake Kaskaskia River	Ag. & Urb	1938/1958	1967
Sid Simpson, IL River at Beardstown	Urban	1950	1967
Eau Galle River	Urban	1958	1968
Root River and Rush Creek at Rushford	Urban	1958	1969
Red Rock Dam and Lake	MP	1936	1969
Lake Shelbyville, Kaskaskia River	Ag.	1958	1970
Des Moines	Urban	1944	1971
Rend Lake	MP	1962	1972
Zumbro River (Lower Reach)	Ag.	1965	1974
Big Stone Lake - Whetstone River	Ag.	1965	1974
Dively Drainage & Levee Dist No. 23	Ag.	1958	1975
Marshalltown, Iowa River	Urban	1965	1977
Saylorville Lake	MP	1958	1977
Remedial Work - Mouth of Sangamon River	Wildlife	1962	1977
Ottumwa	Urban	1965	1977
Carbondale Model City Neighborhood	Urban	1970	1979
New Athens; Kaskaskia River	Urban	1958	1981
Evansdale, Cedar River	Urban	1965	1982
Waterloo, Cedar River	Urban	1965	1985
McGee Creek Drainage & Levee Dist	Ag.	1962	1986

Table 2.2
Upper and Middle Mississippi River Tributaries
Flood Control Projects
Project Type, Authorization Date and Completion Date
1927-1995

Clarence Cannon Dam & Mark Twain Lake (Salt River)	MP	1962	1987
Bannockburn Reservoir	Urban	1986	1988
Milan, Rock River	Urban	1968	1988
Rockford IL, Kent Creek	Urban	1962	1988
Mankato & North Mankato	Urban	1976	1989
Deerfield Reservoir	Urban		[1992]
Green Oaks Reservoir	Urban		[1992]
Marshall	Urban	1986	[1995]
Lost Creek Drainage & Levee Dist	Ag.	1928	
Chicagoland Underflow: McCook & Thornton	Urban	1988	
Crane Creek Drainage & Levee Dist	Ag.	1928	
Mankato & North Mankato	Urban	1958	
Lacy, Langellier, West Matanzao &	Ag.	1928	
Coal Creek Drainage & Levee Dist	Ag.	1936	
Portage	Urban	1986	underway
North Branch, Chicago River: 3 Reservoirs	Urban	1986	underway
Meramec River Basin: Valley Park Levees	Urban		underway
Chicagoland Underflow Plan (O'Hare)	Urban	1986	underway
McCook Reservoir	Urban	1988	underway
Thornton Reservoir	Urban	1988	underway
Rochester	Urban	1974	Underway
Chaska, Minnesota River	Urban	1976	Underway
Houston	Urban	1986	Underway
Big Lake Drainage &Levee District	Ag.	1936	?

After visiting 52 cities, the board determined that no single flood protection measure was enough and that needs varied from basin to basin. The board concluded that the Nation needed a flexible program administered under Federal authority.[63] The board also reported that most damage caused by floods resulted from "unregulated encroachment on the flood plains...." In response to this, say Jamie and Dorothy Moore, authors of *The Army Corps of Engineers and the Evolution of Federal Flood Plain Management Policy*, "the corps endorsed the idea of moving valuable property beyond the flood limits...."[64] Much of this summary is based on their work.

As America changed from an agricultural Nation into an urban one and as stress mounted on its land resources, pressure continued on Congress to enact a national flood protection program. The disastrous 1927 flood on the lower Mississippi River focused American attention on floodplain management. The flood also raised important questions about the best flood protection measures and about the Federal Government's role in flood control. Congress authorized the 1928 Flood Control Act in response. Under this act, Congress provided for some new alternatives such as fuse plugs and floodways. But the act further demonstrated that many Americans believed that protecting floodplains was in the national interest and reaffirmed the belief in structural measures.[65] Reflecting this philosophy, the 1936 Flood Control Act included structural solutions only.[66]

In the 1938 Flood Control Act, Congress, for the first time, provided for evacuating areas threatened by repeated flooding. Section 3 of this act allowed for the abandoning of the floodplain where the cost of constructing levees or floodwalls could be "substantially reduced" by removing the structures that would be protected. The money saved by not building the levee or floodwall could be used toward the "rehabilitation" of the people evacuated.[67] Yet Moore and Moore conclude, "the basic assumption was that water could be kept away from people through the use of engineering structures,"[68] and Congress and the Corps continued their focus on structural flood control. The fact that Congress did not select the nonstructural option for any projects on the upper Mississippi River prior to the Prairie du Chien project, which it approved in 1974, demonstrates this focus.

Floodplain regulation did receive serious attention from some individuals as early as the 1930s but not until the 1950s did the discussion intensify. In 1953, the Budget Bureau found that few Americans supported nonstructural flood control measures. The Bureau asked States to consider implementing floodplain zoning rather than adopting structural solutions. The responses were telling. Some States said it was too late and others too impractical for this. Still others reported that the lack of enabling legislation at the State and local levels inhibited the use of nonstructural techniques and would require the Federal Government to assume much of the cost of land acquisition. Finally, the survey showed that most States had not yet considered floodplain restrictions.[69]

In 1955, William Hoyt and Walter B. Langbein published *Floods*. In it, they supported White and argued that property at risk due to flooding was increasing faster than the Nation's ability to protect it. They concluded that this was due to the Nation's rapidly growing urban population and to the building of levees and other flood protection projects.[70] For this reason, Moore and Moore say, the Corps began to examine other measures.[71]

Yet, America was not ready to limit its potential for progress. Following a devastating flood in Kansas and Missouri in 1951, President Harry Truman requested funds to evaluate a flood insurance program but could not get enough support. Not until hurricanes and flooding occurred in the Northeast in 1955 did interest in flood insurance rise again. In August 1956, Congress authorized a flood insurance act. While Congress took no steps to implement the law, Moore and Moore report that its discussion made two points obvious: Federal flood insurance would affect floodplain use, and the Federal Government would have to heavily subsidize the program. Some observers were concerned that the program would encourage further floodplain development.[72]

To examine the issue of floodplain development itself, the Corps sent Francis C. Murphy, a Corps hydrologist from the Seattle District, to the University of Chicago. In a 1958 study entitled *Regulating Flood Plain Development*, Murphy argued that regulating floodplain use was necessary to reduce the cost to the national economy of increasing flood damages. Murphy insisted that regulating land use in the floodplain had not been adequately considered. One reason for this was a lack of adequate data, especially floodplain maps.[73]

In 1958 and 1959, recognizing a shifting mood in America concerning flood damages and taking Murphy's arguments seriously, the Corps actively sought a role in studying floodplain regulation as an alternative to structural projects. In Section 206 of the 1960 Flood Control Act, at the Corps' request, Congress granted the agency the authority to compile and disseminate information on floods and flood damages if sought by a State or responsible local government.[74] Although limited, this program signaled a significant move toward floodplain regulation as a way to limit flood damages, but it was only a signal. Structural measures would remain the cornerstone of Federal floodplain management through the flood of 1993. In the decades following 1960, however, Americans would increasingly consider floodplain regulation, and environmental concerns for the river's floodplains would mature.

Main stem projects completed between 1940 and 1993 represent a major development in the region's flood protection infrastructure, but they would change the landscape, ecology, and streamflow of the Mississippi River little compared to projects built by local interests and the Corps before 1940. Between 1960 and 1980, the Corps finished many of the agricultural projects authorized in the 1950s and early 1960s and began building many of the urban projects authorized during these years. In these two decades, the Engineers completed 25 agricultural and 9 urban flood protection projects for the upper and middle Mississippi River. After 1980, urban projects dominate. From 1980 to the flood of 1993, the Corps dedicated only one agricultural levee and eight urban projects on the main stem.

The greatest change in the upper and middle Mississippi River Basin after 1940 came on tributary rivers. While work by local interests and the Corps on agricultural projects on the Illinois River had dramatically changed this tributary before 1940, few other tributaries had been greatly altered by reclamation and flood protection projects by this time. After 1940, however, and especially after 1960, the basin's tributary rivers would be changed in important ways.

Since 1960, the great majority of the projects completed on the Mississippi River's tributaries have been multiple purpose or urban. Some 30 urban projects have been completed or are underway (See Table 2.2). Exact numbers are difficult to ascertain, given discrepancies in the data. Six of the urban projects are reservoirs. The Eau Galle Dam, completed in 1968, protects the town of Spring Valley, Wisconsin, which lies immediately below it on the Eau Galle River. The five other projects were authorized in the 1986 and 1988 Water Resource Development Acts as part of an urban protection project for Chicago.

Seven reservoirs finished between 1967 and 1987 serve a variety of purposes. The Red

Rock reservoir, completed in 1969, and the Saylorville reservoir, completed in 1977, help protect Des Moines and agricultural lands below from floods on the Des Moines River. Along with the Coralville reservoir (1958), these projects also serve to reduce flood levels on the Mississippi River. In Illinois, the Corps completed the Carlyle dam in 1967 and the Shelbyville dam in 1970, both on the Kaskaskia River. While Carlyle helps defend both agricultural and urban areas, Shelbyville protects primarily agricultural lands. Rend Lake, a multiple-purpose project which has 109,000 acre-feet of storage for flood control, 160,000 acre-feet for joint purposes, and 25,000 acre-feet for conservation and sediment retention, was completed in 1972. This project is located on the Big Muddy River in southern Illinois. In Missouri, the Corps completed the Clarence Cannon Dam and Mark Twain Lake in 1987. This multiple-purpose dam provides hydroelectric power, flood protection and low flow augmentation storage and recreational use. Two dams that provide flood protection but were designed to promote wildlife concerns are the Devil's Kitchen Dam on Grassy Creek, a tributary of the Big Muddy River in Illinois, and the Big Stone Lake-Whetstone River Dam on the upper Minnesota River. The Devil's Kitchen project, completed in 1960, is one of three structures that store water for the Crab Orchard National Wildlife Refuge. The Big Stone Lake-Whetstone River Dam, finished in 1974, provides a conservation pool of 2,800 acres for wildlife purposes. Thus, between 1960 and the flood of 1993, Congress and the Corps expanded the upper and middle Mississippi River basin's urban flood protection infrastructure dramatically.

As the projects authorized and completed since 1960 show, structural solutions have prevailed. Moore and Moore, in their study of the Corps and floodplain management policy, detail the evolution of floodplain policy through the Water Resource Development Act of 1986. They present a steady movement toward a sympathy for--if not the implementation and enforcement of--floodplain restrictions and nonstructural alternatives to flood control projects. Marty Reuss, a senior historian for the Corps, suggests that floodplain regulation has not advanced over the last 30 years as its proponents of the 1960s had hoped.[75] Between 1965 and 1966, the Bureau of the Budget brought together a team of specialists from various agencies, chaired by Gilbert White, to reassess the Government's flood management program. As one focus of their study, they were to examine whether the Nation was developing its floodplains wisely. "Did federal agencies, particularly lending and development agencies, make adequate use of available flood plain information? Did flood disaster insurance have a practical and positive role to play in dealing with the flood damage problem?" Would floodplain insurance promote the traditional approaches to floodplain management?[76] In 1966, based on this report, President Lyndon Johnson issued Executive Order 11296, directing Federal agencies to evaluate the flood hazard potential before locating new buildings in the floodplain. "For the first time, Moore and Moore assert, federal agencies were to incorporate flood planning formally into their programs."[77] In 1968, Congress followed with the National Flood Insurance Act, and in 1973, with the Flood Protection Disaster Act. Under the latter act, Congress required communities wanting Federal assistance for financing or constructing structures in the floodplain to initiate land use restrictions and required individuals to buy flood insurance.[78] Nevertheless, floodplain development and the authorization of structural projects continued. And although the Corps acquired the legislative authority to encourage and implement floodplain restrictions and nonstructural flood control measures, Moore and Moore conclude that Congressional directives kept the Corps' focus on structural projects.[79]

Conflict over its cost and effect stalled the Nation's flood protection program between

1970 and 1986. During this era, Congress passed no major bill for water resources projects. Environmental concerns, budget deficits, less support for water projects, and impasses over the Water Resources Council's *Principles and Standards* were the primary reasons. The *Principles and Standards* had required the Corps to evaluate both the national economic development and environmental quality objectives and to measure the beneficial and negative effects for all projects. It outlined a process and methods of evaluating alternative means solutions, and it made capital intensive projects harder to justify. And under Presidents Jimmy Carter and Ronald Reagan, the Office of Management and Budget viewed the civil works program as "a controllable, discretionary, government expense."[80]

After a 14-year hiatus, Congress passed the Water Resources Development Act of 1986. In this act, nonstructural flood control was given greater status. Yet, Moore and Moore argue, "interest in nonstructural solutions had declined." They conclude that this occurred because:

> Structures had been used for generations and their costs and benefits were well understood. Their physical presence instilled a source of security. Their effects were permanent and, with periodic monitoring, predictable throughout the life of a project.
>
> By contrast, nonstructural measures kept people away from the water, rather than water away from people. They employed unfamiliar and nontraditional activities like zoning and flood preparedness, which require personal involvement, and they called for individual sacrifice, such as paying for flood insurance....Nonstructural measures also restricted the use of the flood plain and required communities to divert the land to other uses, often resulting in lowered local economic growth. Obtaining political acceptance for flood plain zoning would become difficult.[81]

Important changes had occurred in how the country and the region viewed its floodplains. The greatest change came with the environmental movement of the 1960s and afterward. The passage of the National Environmental Policy Act in 1969 and subsequent environmental legislation gave environmental interests a strong say in how water resource projects would be designed and constructed. Building on the work of Will Dilg and the Izaak Walton League, those concerned with the river's ecological health gained far more strength than they had in 1940.

But, environmental interests have not replaced the traditional stakeholders--agricultural and urban occupants--in the use of the river's floodplains. Those traditional occupants and the reasons they located in the floodplain have a deep history, dating well before the 20th century. Rearranging the role and relationship between the various stakeholders must take this history into account. And while Moore and Moore present an invaluable background to the history of national floodplain management policy, the national context does not always explain or is not always in step with the history of the upper and middle Mississippi River or of the Missouri River. The evolution of floodplain occupation and of flood protection policy must be understood at both levels.

<u>The Missouri River</u>

In its natural state, the Missouri River was a meandering river characterized by unstable banks and a rapid current. Major Charles Suter, who surveyed the river in the 1870s, described the Missouri River as having a navigable depth varying from 3 to 9 feet a year and as eroding its banks as much as 2,000 feet annually. Caving banks and silt would prove to be the main problems facing navigation improvement. From the great amount of soil washing into it, the Missouri River received its nickname, the "Big Muddy." As on the Mississippi River, flood protection and navigation improvement would become closely tied, with navigation funds providing for some early levee work. But most flood protection projects on the Missouri River would have to wait for the 1936 Flood Control Act and those that followed it.

As on the upper and middle Mississippi River, navigation improvements represented one of the first efforts to reshape the lower Missouri River. But, Congressional authorization of and funding for navigation improvements on the Missouri River lagged well behind the Mississippi River in the late 19th century. Once authorized, funding was severely limited, and navigation improvements for the Missouri River became piecemeal and short-term. The Corps began removing snags from the lower Missouri River as early as 1832, and continued this work sporadically through the 1870s. Unlike the Mississippi River, where Congress had authorized the 4½-foot channel project in 1878, there was no systematic navigation improvement project for the Missouri River until 1910.

In the 1910 River and Harbor Act, Congress authorized a 6-foot channel for the Missouri River from Kansas City to the river's mouth. A Federal board of engineers recommended that the best way to achieve this goal was through bank stabilization (to prevent erosion) and channel constriction.[82] But flooding, which destroyed improvement works, and the continued controversy over whether the amount of commercial traffic justified Government costs hindered attempts to improve the Missouri River. By the 1930s, only the reach from Kansas City to St. Louis would see some systematic improvement. Work on the 6-foot channel project continued into the early 1940s but did not entice significant traffic, and the project was still not complete by World War II.[83]

Then, in 1945, Congress adopted the Pick-Sloan Plan. Under this plan, which brought navigation, flood control and irrigation in the Missouri River basin under one development master plan, Congress authorized creation of a 9-foot channel from Kansas City to St. Louis. With this project, the river would acquire more traffic.

As on the Mississippi River, the Federal Government had no official role in the construction of flood control projects on the Missouri River during the 19th century. Landowners, municipalities, and the railroads built dikes and levees to protect their properties. However, beginning in the 1890s, Missouri River Basin residents and localities began demanding protection from flooding and bank erosion as part of the Federal Government's efforts to improve navigation.

In 1884, Congress, at the request of Missouri River Basin residents, created the Missouri River Commission (MRC) to oversee the river improvement work. Major Suter served as the Commission's president until 1895. For the 18 years of its existence (Congress abolished the Commission in 1902), the organization worked to stabilize the Missouri River's banks using willow mats weighed down with stones and continued snagging efforts.

Yet, the Missouri River Commission was frustrated by differences in river improvement philosophies between MRC members, Congress, and Missouri Valley residents. While the MRC saw its mission as one of primarily developing the river for transportation, local interests repeatedly demanded protection from flooding and erosion for private and municipal properties along the river's banks. Congress directed the MRC to build projects that fulfilled both aims, but never provided enough funding for the Commission to meet this directive. In fact, in 1890, the MRC suspended its operations for 4 months due to lack of funding. Inadequate funding over the years led to piecemeal efforts rather than the systematic approach Suter had envisioned. The MRC's final report in 1902 showed that, over its 18-year existence, less than half of the money appropriated for its use had been available for systematic navigation improvements, and a large proportion of the appropriations had gone to fund projects for particular localities that were "not wholly connected with navigation."[84] Thus, although there was no Congressional authorization for flood protection work on the Missouri River at that time, such projects were undertaken by the Federal Government.

After the floods of the early 1900s, States in the Missouri River Basin authorized the organization of drainage districts to build flood protection works. Increasingly, these drainage districts came to the Corps of Engineers for help with their flood control efforts. The Secretary of War would then negotiate with the local organization and reach agreement about how the project should proceed.

By the 1910s, the Corps' work to improve navigation on the river had a significant impact on settlement in the floodplain. Bank stabilization and alignment projects on the Missouri River, which the Corps employed to achieve a 6-foot channel, often narrowed the width of the river and opened bottomlands that had previously been inundated for settlement.[85]

From the onset of World War I to the mid-1920s, Congress provided no funding for flood protection on the Missouri River. Then, in the River and Harbor Act of 1925, it called for the preparation of cost estimates for surveys and studies of the navigable streams of the United States and their tributaries for purposes of power development, navigation, flood control, and irrigation. In 1928, the River and Harbor Act called for the Corps to submit projects for flood protection on all the tributary streams of the Mississippi River that were subject to destructive floods. In response to these mandates, the Corps of Engineers produced a massive series of studies (called 308 reports) that examined all aspects of river use.[86]

The Kansas City District undertook a study of the entire Missouri River Basin in response to these Congressional actions. The report, which was completed in 1932, concluded that most of the proposed flood protection projects for the Missouri River Basin were not economically justifiable. The 1932 report, which was mostly the work of Kansas City District Engineer, Captain Theodore Wyman, concluded that levees to protect urban areas were the only flood abatement measures that were economically feasible. Wyman proposed combining urban levees with a modest reservoir system consisting of a dam at Fort Peck and several tributary dams.[87]

In response to Wyman's report, Congress, in the 1936 Flood Control Act, authorized projects at Topeka and Lawrence, Kansas, and at Kansas City. The proposal to build higher levees in lieu of a reservoir to protect Kansas City proved controversial and led to additional studies of the Kansas River Basin. A 1937 report on this area concluded that upstream reservoirs and local flood protection projects were the desired solution to prevent floods in Kansas City. While these studies were ongoing, the Kansas Valley Drainage District and Kansas City went ahead with local protection projects that the Federal Government funded as part of its work relief program during the Great Depression.[88] And in the Flood Control Act of 1938, Congress approved projects on five Kansas River tributaries: the Republican, Smoky Hill, Saline, Salmon, and Blue Rivers. The first dam built as part of this effort was located near Kanapolis, Kansas, on the Smoky Hill River.

Although World War II restricted funding for flood control projects on the Missouri

River, a series of floods in the early 1940s drew Congress' attention to the problem once again. In 1943, the House Flood Control Committee asked the Missouri River Division Engineer, Colonel Lewis Pick, to testify on the region's flooding problems. The Corps assigned Pick the task of writing a report on the subject. The result was "Pick's Plan," which built upon the Flood Control Act of 1938, but added three projects: construction of levees along the Missouri River from Sioux City to St. Louis; building of additional multi-purpose dams on the Missouri River and some tributaries; and construction of a diversion channel in the Dakotas to divert water from the Missouri River during droughts.[89]

At the same time, William G. Sloan wrote a report for the Bureau of Reclamation that focused primarily on irrigation, reclamation, and hydropower development in the Missouri River Basin. Congress combined the two reports and in 1945 passed the "Pick-Sloan Plan." For the first time, a comprehensive system for flood management in the Missouri River Basin was in place. The Pick-Sloan Plan, together with previous flood control legislation for the region (1938 and 1941 Flood Control Acts), created a system consisting of nine major reservoirs, agricultural levees, and numerous urban flood protection projects.[90]

As work under the Pick-Sloan Plan progressed, many of the proposed reservoirs proved highly controversial, because they inundated rich agricultural land. However, the agricultural levees were not controversial and went up quickly after construction started in 1948. Work on the 9-foot channel, which had been approved in the 1944 River and Harbor Act, progressed simultaneously. Navigation improvements and flood protection work began in earnest on the tributaries to the Missouri River in the late 1940s. In 1950 and 1954, Congress adopted proposals that modified the original plan. These included an additional eight reservoirs in the Osage River Basin, three reservoirs in the Kansas River Basin and a dam on the Chariton River. Controversy over the Pick-Sloan reservoirs, however, slowed and in some cases prevented construction of many of the proposed dams.[91] By 1960, two of the dams were completed (Kanapolis and Harlan County), three were in various stages of construction (Turtle, Pomona, Pomme de Terre), while five were in the planning stage (Wilson, Perry, Stockton, Rathburn, and Truman).

Meanwhile, construction on the agricultural levees in the Corps' Kansas City District ceased between 1954 and 1963, after the Department of the Army ordered a restudy of the project. Questions about the economic justification for building the levees and concerns about the effects privately-built levees had on the system prompted the restudy. As the outcome of this review, Congress in 1963 authorized the Corps only to build the levees that the studies had shown to be economically feasible. Under this authorization, 250,000 acres of the 400,000 acres in the floodplain would be protected by agricultural levees. By the early 1970s, 20 percent of these levee projects had either been completed or started (approximately 200 miles of levees).[92]

The Flood Control Act of 1944 and the Pick-Sloan Plan authorized the Corps' Omaha District to construct agricultural levees in numerous locations. Between 1946 and 1950, the Corps built the 46-mile-long Thurman-Hamburg levee on the left bank of the Missouri River in southwestern Iowa and northwestern Missouri and along the Nishnabotna River. Between 1948 and 1952, the Omaha District constructed 41 miles of levees for the Atchinson County Levee District; between 1950 and 1953, the District built the Mill Creek levee, and in Nebraska, the Peru Dike, and the 19.5-mile-long Brownville-Nehema levee. Near Nebraska City, the Corps erected 6 miles of levees and a 14.2-mile-long levee at Mosquito Creek and Sieck near Council Bluffs.

By mid-1954, the Omaha District had spent $13.9 million on agricultural levees; all of these were located south of Omaha and most on the river's left bank. The onset of the Korean War deferred plans for more agricultural levee construction until 1959. Then, between 1959 and 1961, the Corps built 6.3 miles of levees in Richardson County, Nebraska; the 11.4-mile-long Pleasant Valley Levee; the 15-mile-long Watkins-Waulsonsic Ditch levees; and the 14-mile-long Papillon Creek-Platte River levees in Nebraska. All together, between 1954 and 1979, the Omaha District invested $8.3 million on agricultural levees. In 1980, the Omaha District initiated a $13.6 million, 22-mile-long agricultural levee project along Mosquito and Keg Creeks below Council Bluffs. By late 1982, the District had spent a total of $32.5 million on agricultural levee projects.[93]

Most of the flood protection projects on tributaries to the Missouri River in the Corps' Omaha District did not begin until after World War II. These projects included dams, levees, bank stabilization, and alterations in channels. The 1941 Flood Control Act authorized the Cherry Creek Dam near Denver, which was built between 1946 and 1953. Congress authorized the Chatfield Dam in 1950, but its construction was deferred until the flood of 1965 reactivated the project. Construction began in 1967 and was completed in 1973. The Flood Control Act of 1958 authorized $13.3 million for the Salt Creek Basin project, which included 12 dams (later reduced to 10), a levee, and a channel system on Salt Creek at Lincoln, Nebraska. The Corps completed this project by 1968. The Flood Control Act of 1968 authorized a system of 21 dams and reservoirs for Papillon Creek at a cost of $26.5 million. However, only two of these dams would be built, as controversy over the need for the project prevented its completion. On the east side of the Missouri River, the 1954 Flood Control Act authorized the Corps to construct major flood protection projects on the Big Sioux River (between Sioux Falls and Sioux City) and on the Floyd River (at Sioux City).[94]

Economic and Social Forces

The earliest settlement and development patterns of the Midwest were often based on the access provided by major rivers in meeting transportation, power, and water needs. Communities were founded and grew as trade centers at locations along rivers because floodplain lands were most easily and cheaply developed and commerce was most readily serviced by access to the river. Once town sites were well established, there continued to be a comparative economic advantage for subsequent commercial and residential development to be located close to town centers. In the 19th century, before intensive industrialization and mass communications, people accepted the inconvenience caused by occasional flooding, and had a greater appreciation of natural forces.

At first, floodplain farmers produced crops for themselves and local markets. But as they began producing crops for regional and national markets, the river became even more critical as a transportation route. As generation after generation of floodplain farmers succeeded each other, families developed strong ties to their farms. As in the past, many counties in the rural Midwest depend on a healthy agricultural sector to provide the tax base and commercial revenues that support local schools and provide for other public services. To forego agricultural production in areas subject to flooding, therefore, incurs both economic and social costs.

Contemporary society's emphasis on speed, timeliness, and reliability causes floods to be viewed as a much more disruptive menace. Technological capabilities and associated economic and social values have led to approaches that seek to control floods, and to seek and assign responsibility for the causes when flooding occurs. The severity of flooding is marked by the number of lives lost, the economic damages suffered, and the losses experienced by people as they are forced from their homes and daily routines. All of this is communicated by the mass media as the flood happens. Human interest allows us to identify with the individuals who have been affected and to question why such an event could be "allowed" to happen.

Social and economic issues are raised after each flood disaster. What can be done to prevent loss of life caused by flooding? Are flood victims disproportionately represented by those with lower incomes? Are affordable housing alternatives available? Why does there appear to be so much persistence in returning to and restoring flood damaged homes and other facilities? What can be done to improve society's understanding of the risks of flooding and of steps that can be taken to avoid repetitive flood losses?

These are all reasonable questions. The Midwest Flood of 1993 was so extreme in magnitude and duration, however, that it has caused many people to take a step back and consider these questions from a different perspective. Hence, the need to recognize economic and social forces at work in understanding how floodplains have been developed, and to take these forces into account as alternative floodplain management measures are considered.

Institutional Forces

The many multifaceted stakeholders of the Mississippi and Missouri Rivers and their floodplains have various levels of acceptance (or non-acceptance) of floodplain management concepts and are all positioning themselves for their interest in the floodplain. The primary stakeholders may be categorized within one or more of the following areas:

- Federal agencies
- State and local agencies
- Tribal governments
- Residential
- Agriculture
- Levee/drainage districts
- Industrial/manufacturing
- Environmental/wildlife groups
- Recreationists
- Transportation
- Cultural and historic preservation
- Organizations and interest groups

There are Federal and State agencies, as well as local governments, that are representing the interests of the general public in each of the above areas. There are also river basin associations, interagency committees, and alliances such as the Upper Mississippi River Basin Association and the Missouri River Basin Association, Interagency Floodplain Management Review Committee, and Coast Alliance that have been established in efforts to gain a more focused direction among the governmental agencies. In addition to the agencies and local governmental offices performing formal roles, as established by legislation and statutes, there are many organizations and interest groups that have varying degrees of influence on the development of new policies and programs. Appendix D provides a list of some of the key organizations and their purposes.

Also, the United States Government has a unique legal relationship with Native American tribal governments. The Government-to-Government memo dated May 1994 identified a commitment to building a more effective, respectful working relationship with federally recognized Native American tribal governments. Guidelines were included in the memo to ensure that the rights of sovereign tribal governments are fully respected. Because tribal governments have authorization to create their own floodplain policies and programs, they should be considered in any partnering efforts for changes in floodplain management. Those tribes within the study region are also included in the Institutional listing.

An analysis of institutional forces can be a valuable tool in understanding, evaluating, and analyzing the institutional setting: legality and compliance, political conflicts, social and cultural values, and administrative effectiveness. "In our complex world, decisions which impact the public interest require complex coordination between all concerned interests, and due consideration of the legal and economic factors, political feasibility, and examination of the powers and authority of public bodies which are charged with responsibility for the public interest" (Bro et al., 1976:5). Political interaction from individuals, groups, and organizations is necessary for consensus building. Opposition interests that fail to show up at public meetings may surface later to stall implementation. Conflict is unavoidable, but conflict between interest groups and agencies, as well as interagency conflict, needs to be identified and opened for discussion.

The success of any change in floodplain management will depend on gaining support from local communities and citizens, since most decisions on floodplain land use are determined by local policy. Communities, especially floodplain landowners, perceive the loss of jobs and economic productivity, and are reluctant to change. But communities stand to gain the most from improvements that generate economic and development opportunities such as improved water quality and supply, improved recreational/fishing/hunting opportunities, improved aesthetics and land values. River focused community revitalization projects work with bottom-up-local involvement. Local communities will need support in making floodplain changes to maintain economic vitality, but it will require local empowerment, effective new incentives, removal of disincentives, and an effective implementation framework.

Policies and Programs

Floodplain land use is influenced by a wide range of policies and programs that stem from various governmental agencies and bodies. In this assessment, seven categories of policies and programs have been examined in the context of the 1993 flood, and initial evaluations have been completed of how changes in these areas might have affected the flood losses and impacts to floodplain resources that were experienced. The seven categories are:

* National Flood Insurance Program regulations
* State floodplain management and zoning practices
* Local floodplain management and zoning practices
* Community relocation, flood hazard mitigation, and land use conversion programs
* Flood disaster relief programs
* Floodplain wetland restoration policies
* Agricultural support policies related to floodplain use.

A description of specific measures examined within these policy/program categories is presented in Chapter 6 of this report, and the analysis completed in each case is contained in the Evaluation chapter (Chapter 7).

Structural flood protection projects, in the form of levee or floodwall construction and the building of dams and reservoirs on rivers, may also lead people, businesses, and communities to make decisions regarding continued floodplain development that increase the potential for large amounts of damage when extraordinary flooding occurs. The "action alternatives" examined in this assessment that affect hydrologic and hydraulic conditions related to riverine flooding are described in Chapter 8 of this report.

Of particular interest is how these policies, programs, and projects have functioned to create incentives or disincentives that have helped to shape how floodplains are used. There are economic and other forces that past actions have set into motion and appear to have led to increasing exposure to damages from extraordinary flood events.

A number of questions have been raised concerning how past actions have influenced floodplain development and use. Examples of the kinds of questions and issues raised are shown below:

* How well is the National Flood Insurance Program functioning in covering exposure to riverine flood risk?
* Is the current definition of flood risk (the "100-year" flood zone) adequate?
* Can floodplain management programs at the State and local level be improved in increasing awareness of the potential for flooding and in reducing exposure to flood damages?
* Have local land use and zoning practices been effective in preventing new development in locations subject to substantial flood risk?
* Do flood control projects induce development in floodplain locations that would otherwise be avoided? If so, are the effects of induced development properly accounted for?
* Do Federal disaster assistance programs encourage continued exposure to substantial flood damages?
* Can floodplain wetland restoration programs have a significant impact in reducing the potential for flooding?
* Do agricultural incentive programs encourage farming in floodplains subject to very frequent flooding?

Prevailing thinking suggests that floodplain management practices ought to be directed at achieving two primary objectives: (1) that reductions in loss of life, damages, and government expenditures caused by flooding should be accomplished; and (2) that the natural resource values of floodplains should be enhanced for a number of reasons, including the potential for reduced flooding and exposure to flood damages. Yet, a fundamental tension exists, in that floodplains are also economically attractive locations for a number of development purposes, and have been historically. There are potentially conflicting forces regarding floodplain use and development that involve trade-offs between the value of economic activity that benefits from its floodplain location, and the costs, both the impacts to natural resources as floodplain development takes place and the impacts to human resources when extraordinary flooding occurs. The ability of society to address these tensions over how floodplains are used requires an understanding of many economic, social, and environmental factors. The challenge is to ensure that decisions regarding floodplain use are made with full recognition and acceptance of the risks and potential costs associated with living, working, or investing in floodplain locations.

The analytical approach taken in this assessment is to examine these questions and issues, among others, with specific reference to the 1993 Midwest flood. The evaluation process that has been developed is explained in Chapter 4 of this report.

The institutional forces discussed in the previous section, together with the many policies, programs, and goals of each of these "players," result in a complex set of objectives for the floodplain. It is essential to identify areas of conflict, but more importantly to focus on commonly acceptable site specific uses of the floodplain that meet systemic goals. A more comprehensive analysis of the interaction of policies, programs, and goals of these "players" would help identify those areas in common and attain an enhanced understanding of floodplain management objectives.

Findings

2-a) The upper and middle Mississippi River's landscape as it existed on the eve of the 1993 flood had, for the most part, been shaped by 1940, largely by navigation projects and agricultural levees. Urban projects had yet to be built. The greatest changes in the upper Mississippi River Basin after 1940 would occur in the river's tributaries and uplands. From 1960 to 1993, the Corps would build most of the urban projects and multiple purpose dams in the basin. The expected role of the Federal Government in protecting floodplain occupants evolved over the past 50 years. Floodplain regulation received little attention before 1960, but policies have been greatly expanded and institutionalized since the mid-1960's.

2-b) The Federal philosophy of floodplain management recognizes that flood damage avoidance should generally be the first defense against flooding, complemented by nonstructural and structural flood protection measures, where appropriate, with public education and flood insurance included as essential components to address the residual risk of flooding.

2-c) The inventory list compiled with this assessment of institutions, organizations, and interest groups is another step in further understanding of institutional forces. A more comprehensive analysis of the interaction of policies, programs, and goals of these "players" would add value to the understanding of floodplain management objectives.

CHAPTER 3 - EXISTING FLOODPLAIN RESOURCES AND IMPACTS OF THE 1993 FLOOD

Floodplain/Watershed Relationships

The upper Mississippi River Basin encompasses the areas drained by the Mississippi River above the confluence with the Ohio River at Cairo, Illinois, and includes the entire Missouri River Basin which drains most of the northern Great Plains. The upper Mississippi River Basin drains approximately 714,000 square miles. Although the Floodplain Management Assessment (FPMA) draws a distinction between the watershed and floodplains, it is acknowledged that they are intimately connected. The river-floodplain systems are the pathways through which surface water runoff and groundwater flow are transferred out of the river basin or watershed. While the geophysical and surface characteristics of the floodplain may define its capacity, extent and functions, it is the characteristics of the upland portion of the watershed which define the concentration, distribution, and dispersal of water to the floodplains.

The upper Mississippi River Basin is composed of many smaller sub-watersheds that vary widely in physical characteristics such as topography, land use, soil types, drainage network, and wetland type and extent. These characteristics determine water storage and runoff potential. Some of these sub-watersheds are considered closed basins: the storage volume in the closed basin must be filled to the level of the lowest outlet before this basin begins to contribute to flows in a river or stream outside the basin. This type of basin by definition has large quantities of surface storage (lakes, wetlands, reservoirs, or other surface depressions). Local flooding can occur in the local basin as water levels rise, even though the basin is not contributing to flooding outside the basin. In open systems, surface water runoff generally flows to a stream and out of the system. If the high-elevation area separating a closed basin from a stream is overtopped by a flood event or breached by a drainage channel, the closed basin becomes part of the open contributing system, and rapidly adds flows to downstream channels. Many of the constructed open ditch drainage systems present today cause closed systems to function like open systems (SAST, 1994).

The upland watershed characteristics across the upper Mississippi River Basin have changed considerably over the past 100 years. The conversion of the majority of the Great Plains from a prairie/wetland landscape to one of urban/agricultural land use has greatly altered the quantity, quality and timing of waters delivered to the rivers. In many areas, the land has been altered to drain water as quickly as possible to help reduce crop losses. The draining and filling of wetlands has changed the manner and rate at which water enters tributary streams in complex ways that cannot easily be explained or modeled. How different sizes, shapes, numbers, kinds, and spatial configurations of wetlands and adjacent habitats and land use influence the distributions not only of water, but of energy, nutrients, pollutants, and species, is presently known in only a general, fragmented, or localized way. A systematic view of these interactions that links spatial and temporal variation within the context of a wetland landscape altered by human activities has not yet emerged (Bedford and Preston, 1988). However, there is considerable evidence that inputs to floodplains of sediment, nutrients, and chemicals from upland watersheds can have major impacts on floodplain ecosystem health and integrity (UMRCC, 1993; Coastal America, 1994; Freshwater Foundation, 1994; Lubinski, 1993).

The floodplain components of the watershed are the lowlands adjoining the channels of rivers and streams, or the shorelines of lakes, wetlands, or other standing bodies of water. They are lands that have been or may be inundated by floodwater. Floodplains are shaped by dynamic physical and biological processes including climate, the hydrologic cycle, erosion and deposition, extreme natural events, and other human-induced forces. Floodplains are among the most productive of the planet's ecosystems, and this productivity is tightly linked to their function of temporarily holding and conveying floodwaters. The unique nature of the floodplain is a result of both short-term and long-term fluvial processes. The importance of the river to the floodplain and the floodplain to the river cannot be overemphasized. If either is altered, the other will also change in time because floodplains and their rivers are in a continual dynamic balance between building of structure and removal of structure.

When considering the natural functions of and outputs generated by floodplains, the flooding of the floodplain is important for the maintenance of the floodplain-river ecosystem. The flooding water and subsequent groundwater levels are the main determinants of the type and productivity of vegetation found there. Flooding waters also bring nutrient-rich sediments to the floodplain, export organic and inorganic material from the floodplain, and serve as a primary agent for long-term aggradation and degradation of the floodplain. The hydroperiod of the floodplain, which includes its duration, intensity, and timing, is the ultimate determinant of the ecosystem structure and function (Mitsch and Gosselink, 1986).

Most of the plants and animals inhabiting the floodplain have adapted to a flood-pulse: an annual advance and retreat of floodwaters onto the floodplain (Junk et al., 1989). During a flood in unconstricted floodplains, aquatic organisms migrate out of the channel and onto the floodplain to use the newly available habitats and resources. As floodwaters recede, nutrients and organic matter from the floodplain are funneled back into the river along with newly produced biomass (fish, invertebrates, etc.). This flood-pulse concept points out the importance of the lateral links of the river-floodplain system, in addition to the longitudinal (upstream/downstream) component for maintaining a healthy, functioning river-floodplain ecosystem (Sparks, 1995).

Obviously, however, not all uses of the floodplain are compatible with a natural hydroperiod or flooding characteristic. For example, restricting flooding of the floodplain is usually required to minimize the loss of crops and damages to property that exist in the floodplain. Currently, there are several systems of levees in place that reduce the flood frequency to many urban and agricultural floodplain use areas. The development of a flood control system on the Missouri and Mississippi Rivers to support these activities has been discussed in Chapter 2. Settlement and subsequent development in floodplains have resulted in changes in floodplain physical characteristics that are analogous to changes in the upland watershed. Urban and agricultural development, coupled with the construction of levees, dams, and navigation facilities, and wetland drainage have resulted in complex changes in the flow characteristics of the river-floodplain system. These different uses of the floodplain represent choices made by society that almost always result in trade-offs. For example, levees constructed to enhance agricultural use of the rich alluvial soils or to protect urban areas in turn affect biological productivity through the elimination of the flood-pulse and its associated processes.

The FPMA focuses primarily on what effects changes in the floodplain have had on determining the type and amount of damages that occurred with the 1993 flood. It also evaluates what the possible outcomes would have been under a number of alternative approaches, including one emphasizing greater consideration of the natural and cultural values of the floodplain.

Since it was impossible to address a total watershed model or fully develop quantitative data within the time frame available for this assessment, the assessment framework considers comparative impacts of various alternatives through a combination of systemic floodplain evaluations together with more specific impact reach studies. Selected sub-basin watersheds in the upper reaches were also examined to determine what actions could be pursued that would reduce the magnitude and slow the timing of runoff to the major river corridors.

Floodplain Outputs/Values

The outputs and values of floodplains can be considered from many perspectives. Throughout the history of the United States, the prevailing view has been that humans should use and modify the natural environment, including floodplains, to meet their needs, and to a large extent this has occurred. Many of the decisions to develop and modify the floodplain were made before the complex processes that control river-floodplain outputs were known. The cumulative impacts of localized floodplain actions are still seldom considered or evaluated.

The current floodplain outputs and associated damages from the 1993 flood are a direct result of past decisions made regarding appropriate use of the floodplain. Often, decisions made at the local level do not consider or cannot predict effects that may occur in other parts of the system. Similarly, decisions made on a national or regional scale may not adequately address all the social, economic, or environmental ramifications on the local scale. In any case, these decisions usually require a trade-off between one output and another, and regardless, all these decisions are associated with a cost. Some current floodplain outputs require considerable government investment (infrastructure or disaster relief) to be sustained, while to attain high levels of other outputs would require major disruption to local communities or individuals. Some floodplain outputs are simply incompatible with each other, and decisions regarding the most appropriate or desired use must be made. Sometimes the political process is the only way that incompatible uses are resolved.

Many of the products and services generated by floodplains are valuable resources for society. They are public goods, recognized under the public trust doctrine of public law, and have no commercial value for the private owner (Jahn, 1978; Bardecki, 1984). This is an important consideration when weighing the range of potential outputs from floodplains, because these outputs are a combination of private and societal goods, services, and values. A problem arises when comparing these outputs because it is difficult to find a common scale upon which to measure them.

The market mechanism of supply and demand is not well suited for evaluating and allocating public goods. A private landowner's decision to modify the use of the floodplain is based largely on internalized (private) costs and benefits. Since many floodplain benefits or commodities do not compete in the marketplace, they cannot be realized by the landowner. Floodplains are multiple-value systems; e.g., some areas may be more valuable for waterfowl, other areas may be more valuable for fish production, some areas may be more valuable for agricultural production, and other areas may be most valuable for their flood storage function. It has been suggested that no more than one-sixth of the total societal benefits of wetlands can be realized by a private owner, even though the owner may bear all the costs (taxes, etc.) of ownership. Clearly, it is difficult to compare this wide range of values with a single index such as dollars. Attempts have been made to place a dollar value on the benefits of wetlands, floodplains, and other ecosystems, but none are wholly satisfactory or universally accepted (Smith, 1992; Farber and Costanza, 1987; Scodari, 1990; others).

Changes in the way society values the wise use of natural resources found in the Nation's river corridors can be seen in the many State and Federal laws enacted since the 1960's. For example, with passage of the National Environmental Policy Act (1969), Congress formally recognized that environmental resources depend upon the functioning of complex natural systems, and declared environmental quality as a national goal. Further, the Interagency Floodplain Management Task Force established two broad objectives for a unified national program for floodplain management: 1) to reduce loss of life and property due to floods; and 2) to minimize losses of natural and beneficial resources from changes in land use by promoting the wise use and management of the Nation's floodplains. However, the fact that various government programs are in place today that are inconsistent with these objectives demonstrates that a diversity of views regarding appropriate outputs from alternative uses of floodplain resources still exists.

Some of the natural services provided by floodplains include flood storage, conveyance, water purification, fish and wildlife habitat, fish and wildlife production, biological diversity, and recreational opportunities. In addition, floodplains offer cultivated resource values including products from agriculture, aquaculture, and forestry. Given adequate protection from floodwaters, floodplains also provide commercial and residential outputs. A partial list of floodplain outputs, derived from the Federal Interagency Floodplain Management Task Force Report (1992), is shown in Table 3-1. A thorough description of these resources can also be found in that report.

Table 3-1. River/Floodplain Resources and Outputs.

<u>Water Resources</u>

Natural Flood and Erosion Control
- Reduce flood velocities
- Reduce flood peaks
- Reduce wind and wave impacts

Surface Water Quality Maintenance
- Reduce sediment loads
- Filter nutrients and impurities

Process Organic and Chemical Wastes

Groundwater Maintenance
- Promote infiltration and recharge
- Enhance base flow

<u>Living Resources</u>

Support Vegetation
- Maintain high productivity
- Maintain natural genetic diversity

Provide Habitat
- Breeding and feeding areas (fish and wildlife)
- Protect rare and endangered species
- Corridors for migration

Support Other Ecosystems
- Produce and export organic matter

<u>Land Based Resources</u>

Maintain Harvest of Natural Products
- Cultivation of fish and shellfish
- Create and enhance forest lands
- Provide harvest of fur resources

Maintain Harvest of Agricultural Products
- Create and enhance agricultural lands

Provide Residential/Commercial Opportunities
- Businesses and Homes

<u>Cultural/Recreational Resources</u>

Provide Education and Scientific Study Opportunities
- Ecological studies
- Historical and archeological sites

Recreational Opportunities
- Provide for active and consumptive uses
- Provide areas for passive activities
- Provide open space and aesthetic values

An understanding of the various uses and values in the floodplain and their effect on each other is the first step in developing a multi-objective approach to management of the floodplain. The FPMA has addressed many of these floodplain outputs and values as impacts relative to the various structural and nonstructural floodplain management evaluated approaches.

Land Use/Land Cover

The distribution and degree of damages and impacts experienced from the flood of 1993 reflect the land use and settlement patterns within and adjacent to the floodplain. Land Cover refers to the type of feature present on the earth's surface. Land Use relates to the human activity associated with a piece of land. The estimates of land use and land cover for the FPMA (except within the Omaha District) were made from data developed for the Scientific Assessment and Strategy Team (SAST) from 1990-1992 August/September Thematic Mapper satellite imagery, with categories corresponding to the Anderson Level 1 classification (Anderson et al., 1976). For the Omaha District, land use data from the Missouri River Flood Plain Atlas (1982) was used.

Table 3-2 is provided to show the general picture of land use within the FPMA study area and the degree of 1993 flooding relative to those land uses. However, for the various FPMA analyses that were conducted, the actual base acreages may differ from this table. As described later in this chapter and in Chapter 5, it was not reasonable to identify one unique study area for defining base conditions for economic, hydraulic, and environmental analysis because of the variability in data quality and extent of coverage among the various sources of data.

Differences will be apparent when comparing the data in Table 3-2 with other land use/land cover databases. For example, the data presented in the Interagency Floodplain Management Review Committee (IFMRC) report (1994) will vary somewhat because of different overall study areas used for the two assessments. Differences for Mississippi River Districts will also vary from data developed by the Environmental Management Technical Center (EMTC) because of differences in classification categories, ground truth verification, and extent of floodplain used as a base. It should also be noted that classification of satellite imagery is typically only 85 percent accurate, and this could also account for some differences between different studies.

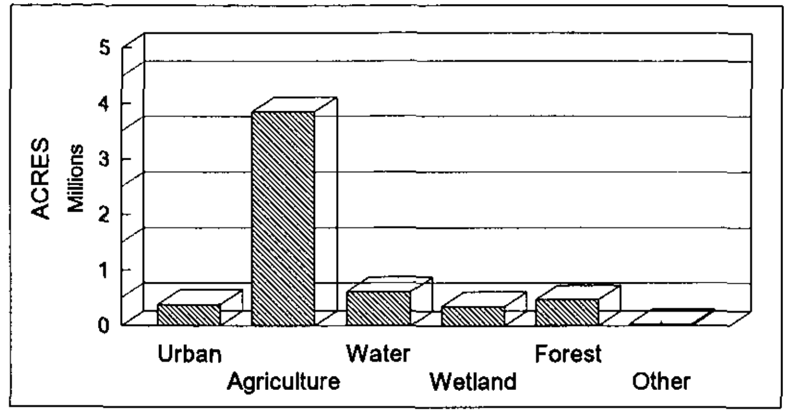
In Table 3-2, it is apparent how land use characteristics of the floodplain system change as one moves downriver. Obvious differences between the Mississippi and Missouri Rivers are also apparent, particularly the high extent of agricultural land use on the Missouri River. Although wetland and water show a greater percentage of land use in more upstream locations of the Mississippi River, with agriculture dominating in lower reaches, agriculture is dominant throughout the Kansas City and Omaha reaches of the Missouri River. Urban use is also higher on the Mississippi River than in the Missouri River floodplain, with the highest overall percentage in the St. Paul District reach. The floodplain is narrower here, however, and higher total acres of urban use are seen in lower reaches. Excluding the water category, "natural" land use (wetland and forest) accounts for only 10 percent of the floodplain on the Missouri River, but accounts for 15 to 25 percent of the land use on the Mississippi River.

The IFMRC Report (1994) provides a good overall description of the history of development and current trends in the upper Mississippi River Basin land use. Portions of that narrative are repeated or modified in the discussion that follows.

Management of the Nation's floodplains involves a variety of disciplines, governments, and private sector activities, all of which interact in complex ways to influence the priorities for land use in the floodplain. The floodplains along the main stem Mississippi and Missouri Rivers and the major tributaries that were inundated generally are used for agriculture, and most areas are sparsely populated. Throughout most of the area, river towns are protected by urban levees, or they are located primarily on a bluff. Floodwaters thus inundated neighborhoods rather than entire communities. Residences, businesses, and industries received damages in bottomland areas and along tributaries near Kansas City and St. Louis. Development in these urban areas, however, is largely in the uplands or protected by urban levees that provide flood protection. As a point of comparison, significantly fewer people were affected by the Midwest Flood of 1993 than by the 1927 flood on the lower Mississippi River.

Table 3-2. Land Use/Land Cover for FPMA study area floodplain.

Land use/cover category	Total for Study Area Floodplain (acres)	Use in Floodplain	Flood Extent (acres)	Percent of Flooded
Urban	379,500	6%	73,920	3%
Agriculture	4,044,100	68%	1,502,685	56%
Water	620,900	11%	589,218	22%
Wetland	349,123	6%	205,397	8%
Forest	482,760	8%	289,700	11%
Other	28,400	0%	24,361	1%
Total	5,904,783		2,685,281	100%



Land use/cover category	Omaha		Kansas City		St. Paul		Rock Island		St. Louis	
	Floodplain (acres)	Percent in Floodplain	Floodplain (acres)	Percent in Floodplain	Floodplain (acres)	Percent in Floodplain	Floodplain (acres)	Percent in Floodplain	Floodplain (acres)	Percent in Floodplain
Urban	79,000	6%	67,000	5%	60,700	11%	87,900	7%	84,900	7%
Agriculture	1,185,500	86%	1,017,600	77%	167,100	31%	776,600	61%	897,300	79%
Water	37,100	3%	93,100	7%	164,300	30%	211,900	17%	114,500	10%
Wetland	44,200	3%	58,700	4%	74,800	14%	65,100	5%	106,323	9%
Forest	6,100	0%	90,800	7%	76,100	14%	137,500	11%	172,260	15%
Other	19,900	1%	2,200	0%	600	0%	900	0%	4,800	0%
Total	1,371,800		1,329,400		543,600		1,279,900		1,380,083	

Land use/cover category	Omaha		Kansas City		St. Paul		Rock Island		St. Louis	
	Flood Extent (acres)	Percent of Flooded	Flood Extent (acres)	Percent of Flooded	Flood Extent (acres)	Percent of Flooded	Flood Extent (acres)	Percent of Flooded	Flood Extent (acres)	Percent of Flooded
Urban	500	0%	26,700	3%	16,000	4%	20,320	3%	10,400	2%
Agriculture	89,800	58%	703,200	77%	72,800	20%	268,485	44%	368,400	57%
Water	35,400	23%	89,400	10%	161,200	45%	199,418	32%	103,800	16%
Wetland	15,200	10%	29,400	3%	59,300	17%	41,097	7%	60,400	9%
Forest	12,200	8%	44,300	5%	48,500	14%	86,800	14%	97,900	15%
Other	2,800	2%	15,500	2%	1,200	0%	361	0%	4,500	1%
Total	155,900	100%	908,500	100%	359,000	100%	616,481	100%	645,400	100%

Notes: Forest includes "Upland Forest" and "Forested Wetland" categories from ERI (Appendix C). In some cases Wetland and Forested Wetland data are based on extrapolation of satellite imagery classification compared with NWI data. (See Chapter 3 text for help in interpreting this table, land use/land cover categories, and data coverage).

Above Rock Island, Illinois, the Mississippi River valley is relatively narrow and bottomlands are filled to a large extent by navigation pools - the slack-water pools that form behind navigation dams. Most of the remaining floodplain in this area is contained in wildlife refuges with limited agriculture. Along this reach of the river are scattered towns settled during the steamboat era that have developed as market centers and service areas for agricultural communities. Industries were established in many of these towns to take advantage of river navigation and the railroads that later followed the river valleys. Such towns generally have been protected by urban levees or are largely out of the floodplain. Below Rock Island, the valley widens out to as much as 6 miles. The extensive bottomlands in these areas are protected by agricultural levees and are used for crops. The leveed areas include farmsteads and a few small farm communities entirely within the floodplain.

Missouri River bottomlands, used predominantly for agriculture, are protected to varying degrees by levees. On the fringes of the bottomlands are small farm communities. In the adjoining uplands, a number of larger communities are located on the bluffs above the valley. Developed floodplains with larger urban areas such as Omaha-Council Bluffs, Kansas City, and St. Louis are largely protected by levees. Near Kansas City and St. Louis, several residential, industrial, and commercial areas are built on floodplains behind levees that overtopped or failed in 1993. Other residential, industrial, or commercial areas were flooded along the larger tributary streams in these urban areas. Scattered along the river are rural subdivisions, many of which began as hunting and fishing camps and evolved into year-round communities. These subdivisions provide inexpensive housing in part because of cheap land, lack of services such as sewer and water, limited land use controls, and few building requirements.

On the major tributaries, the patterns of development are much the same as along the Mississippi and Missouri River main stems, although the bottomlands are narrower with fewer farmsteads. The small towns along these tributaries often have flood-prone neighborhoods, but most of the population lives in the adjoining uplands.

Environmental Impacts of the Flood

An actual flood event is not typically considered a negative impact from an environmental perspective, because most of the plants and animals of the natural floodplain have adapted life history strategies that allow them to react to and benefit from floods. Because the particular use of a piece of land is the ultimate determinant of the status of the environmental resources and outputs of that land, land use, as opposed to flood impacts, was the basis for the environmental impact categories chosen for this assessment (see Chapter 4). To measure changes in land use related to various floodplain management options, and thus changes in environmental resources, an environmental resources inventory was conducted for the entire study area floodplain to quantify the existing floodplain resources. This data was compiled by a contractor using existing databases and personal contacts with agency staff from many State and Federal agencies (Appendix C).

Although "land use" and not "flood impacts" was used to assess environmental effects, it is useful to note how the natural environment responded to a flood of the magnitude that occurred in 1993. Flooding can have both beneficial and detrimental impacts to the biota of the floodplain system, however. Impacts to wildlife adjacent to leveed streams could be affected more than in non-leveed areas because of the possibility of levee breaches or breaks where there is a swift influx of water. In an unregulated river, water levels generally rise gradually to flood stages and animals have a longer time period to escape rising water. Flood impacts can also be short-term and/or long-term. For example, the short-term impact of tree mortality creates gaps in the canopy of a forest community, allowing light penetration and new tree growth to occur in these gaps. This process sets back succession and can lead to a more diverse forest community in the long term. The 1993 flood caused substantial tree mortality in the upper Mississippi River system floodplain. The magnitude of flood impacts was correlated with the amplitude and duration of the flood. On the Mississippi River from pool 17 downriver to the open river, 18 to 37 percent of the canopy trees were killed, 70 to 80 percent of the saplings perished, and smaller juvenile trees were nearly completely wiped out (Yin et al., 1994). On the Missouri River, forest stand regeneration was noted in some flooded areas, but some levees reportedly lost considerable vegetative cover due to scour and prolonged inundation (Becker, pers. comm.).

Flooding can allow native species to reintroduce or increase their foothold in areas that have been invaded by tree species not adapted to flooding in bottomland environments (Bhowmik et al., 1993). The floodwater aided in dispersal of oak, hickory, and other seeds to new areas of the floodplain (Allen, 1993). The flood of 1993 also benefited some of the native marsh vegetation by suppressing purple loosestrife, the invading weed which has been displacing the native species (Allen, 1993).

In some areas, predatory species of the riverine environment thrived by feeding on fish which are trapped in shallow areas. Wading or predatory species of birds such as shorebirds, herons, egrets, bald eagles, and hawks benefited by increased food resources such as fish trapped in shallow areas. Mammals such as raccoons and mink likewise benefited. Other bird species such as the endangered least tern had many nests swept away by the rising waters (Allen, 1993).

The flood disrupted attempts at improving wildlife habitat by inundating the 6,600-acre Ted Shanks Conservation area in Missouri. Instead of having 19 separately managed units, that area became a large pool with water up to 20 feet deep in areas, thereby eliminating much of the shallow water needed for feeding areas by some waterfowl (Allen, 1993). The flood also directly destroyed or reduced available food for migratory waterfowl such as the mallard, which relies on the seeds of native plants and on corn left in fields after harvest (Allen, 1993).

For many species of fish, population levels increased due to the abundance of food, increased spawning habitat, and increased juvenile survival due to the large nursery areas resulting from flood inundation. During the 1993 flood, the inundated farms and pastures became some of the most active areas of biological activity (Theiling, 1993). Grass pickerel, bigmouth buffalo, largemouth bass, black crappie, white bass, and bluegill all showed increased spawning and survival as a result of flood conditions.

Flooding can result in an increase in the number of pest species such as mosquitoes due to the increase in habitat available for laying eggs. Another pest species present in the study area is the zebra mussel, but it is unknown how the flood affected this species.

During the flood, a change in the dominant sedimentation process in selected sampled pools of the Mississippi River resulted in scouring of deeper areas and accumulation of sediment in shallower areas, a reversal of the trend during preflood conditions. The net rate of sediment accumulation along sample transects during the flood was less than that during previous surveys (Rogala and Boma, 1994).

Cultural Resources Impacts of the Flood

The Mississippi and Missouri Rivers have been many things to those who have inhabited their floodplains. The rivers have been important transportation corridors; a resource for fish, game, mussels, and wild rice; a boundary between human groups; a recreational resource; and their floodplain terraces home to people for more than 12,000 years. During their travels on these rivers, in their campsites and village sites and their cities, and in the wrecks of their boats, the valleys' inhabitants have left evidence of their presence. Numerous surveys conducted by the Corps of Engineers and other agencies and database compilations have shown that the middle and upper Mississippi River floodplains contain thousands of archeological and historic sites. As the Missouri River has historically meandered extensively across its floodplain, the opportunity of site survival there is low.

Floods affect cultural resources in a number of ways. Archeological sites lying along streambanks can suffer erosion, leading to partial or total loss of the site. Inundation can bury sites in silt and subject them to compaction and moisture damage. After floodwaters recede, the soft ground surface may be tracked, rutted, or otherwise damaged by rescue vehicles, official personnel, and landowners. Standing structures can be swept away or flooded from their basements to their rooftops, leading to the partial or total destruction of the structure. Flood damage to upland archeological and historic sites, while important, cannot be addressed in this report.

The human response to floods can limit or increase damages to archeological and historic sites. Levees protect both types of sites from flooding, but subject both to urban or agricultural development. Retaining excess water in flood storage reservoirs for longer than normal can cause bank erosion around the reservoir. Building emergency levees using nearby fill can destroy archeological sites, and levee failures can cause much more rapid and serious erosion and can sweep buildings away - as was seen so vividly in the television coverage of the flood. The policy/program and action alternatives examined in this study would also affect cultural resources in different ways.

The 1993 flood had a broad range of effects on cultural resources in the upper Mississippi River Basin. Damage to cultural resources was greatest on the Mississippi River in the Rock Island and St. Louis Districts. On a scale of 0 to -5, the extent of damage became increasingly worse as the flood moved downriver. In the St. Paul District, the flood's effect on cultural resources received a -1 rating. For Rock Island District (from Guttenberg, Iowa, to Saverton, Missouri), the flood's effect on cultural resources rated -2, and in St. Louis District (from Saverton to the Ohio River) the flood's effect rated -4 for archeological resources and -3 for historic resources.

Cultural resources impacts on the Missouri River below Rulo, Nebraska, appear to have been minimal. Other than some early 20th century farmstead sites that may have been affected by the flood, Kansas City District reports that no historic standing structures and none of the significant known prehistoric sites were damaged by the flood.

A more detailed discussion of the cultural resources within each District's boundaries is presented in the Cultural Resources appendix (Appendix E).

Economic Impacts of the Flood

One of the initial tasks of this assessment was to obtain information and data on the damages, expenditures, and other losses caused by the Midwest Flood of 1993. Great reliance was placed on already existing sources of data. The 1993 flood damages in most cases exceeded existing stage damage curves, since they do not adequately cover the damages experienced when floods last several months. The extreme duration of the 1993 flood resulted in significantly greater damage than a comparable height of shorter duration. A significant additional effort was required, however, to compile and organize this data so that it would serve as the "base condition" within the evaluation framework that was developed in this assessment. The establishment of "impact categories" as a part of the evaluation framework is covered in Chapter 4 of this report.

A scope of work was prepared that identified the economic and social related impact categories for which data from the 1993 flood would be collected by each of the five Corps Districts in their respective areas. Four of the five Districts obtained contractor assistance to collect relevant data, mostly from secondary sources. Kansas City District did its own data collection. This data was subsequently provided to the Lower Mississippi Valley Division (LMVD) office of the Corps, which was assigned responsibility for preparation of a report summarizing the damages from the Midwest Flood of 1993. The LMVD report is a primary reference document for this assessment. The Interagency Floodplain Management Review Committee report was another important source of information and data related to Federal Government expenditures on emergency response and recovery costs. Other data was obtained directly from Federal agencies such as the Federal Emergency Management Agency (FEMA) and the Department of Agriculture.

As data collection was nearing completion, it was determined that two base conditions were needed for developing comparisons of economic impacts in the evaluation framework. The first base condition (Column A in the summary matrix tables; see Chapter 5 presentation) covers all Federally declared disaster counties contributing flows to the upper Mississippi and lower Missouri River Basins. Approximately 475 counties are included (Figure 3-1, FPMA Disaster Counties). (NOTE: For the nine-State Midwest region as a whole, more than 525 counties were included under disaster declarations. Those not being considered in this floodplain management assessment are outside the upper Mississippi and lower Missouri River drainage basins).

The second base condition (Column B) includes only those Federally declared disaster counties that are adjacent to the main stems of the two rivers or to their major tributaries that were the subject of separate impact reach analyses (Figure 3-1, Impact Study Reach Counties). This set covers floodplains of major rivers in the region being examined in this assessment and includes approximately 120 counties. Most of the impact comparisons that are developed in this assessment focus on this limited set of counties in Column B of the summary evaluation tables.

Environmental resource categories, data and information concentrated specifically on floodplains in river segments corresponding to the Column B counties. No environmental resource inventory for this floodplain management assessment was conducted in upland watershed areas. The focus for data collection on critical facilities was likewise concentrated on the floodplains corresponding to the Column B counties.

Each District has developed its own data for the two base conditions with the exception of St. Louis District, where all counties within its boundaries are included in both Columns A and B. For all of the economic and risk impact categories, information and data were most readily available or able to be developed at the county level. A remaining challenge is to be able to analyze and evaluate economic and social data on the basis of floodplain location. A start has been made in organizing some types of information and data on this basis, but a systemic portrayal of specific economic and social data for many of the issues of interest for basins and main stems as large as the lower Missouri and upper Mississippi Rivers remains to be accomplished.

In the following section, both regionwide impacts and impacts within FPMA study reach counties are discussed. Damages or impacts that relate specifically to areas examined in this assessment are identified as such.

At least half the damages incurred in the Midwest region during the 1993 event were losses in agricultural production. A very conservative estimate, based largely on government assistance to farmers in the form of crop insurance and disaster relief, is that at least \$3.85 billion in agricultural damages were incurred for all counties in the upper Mississippi and lower Missouri River Basins.

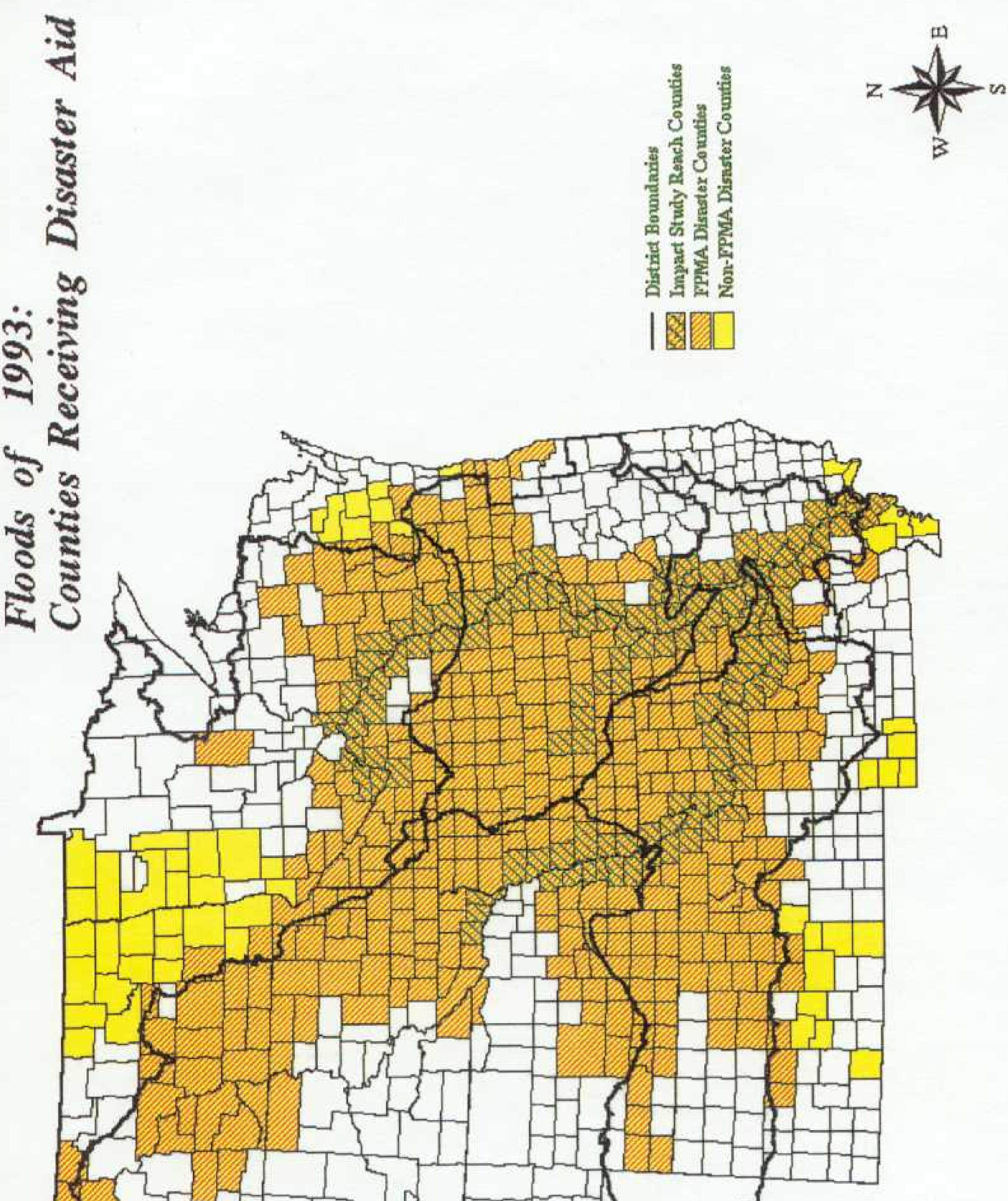

Floods of 1993:
Counties Receiving Disaster Aid
District Boundaries
Impact Study Reach Counties
FPMA Disaster Counties
Non-FPMA Disaster Counties
N
E
S
W

Figure 3-1

This was a region-wide impact, extending far beyond the floodplains of the main stem rivers and major tributaries. In the Base Condition, Column B "floodplain" counties for the impacts summary tables presented in Chapter 5 of this report, some 21 percent ($817 million) of *the total regional agricultural production losses* are estimated to have occurred, despite these counties being about 25 percent of all the Federally declared disaster counties being examined within this assessment. A somewhat greater share of the losses appears to have been experienced in counties in upland areas of major watersheds where extensive, persistent rainfall made farming extremely difficult, if not impossible, on many of the more than 35 million farm acres damaged (NRCS, pers. comm.) during the summer of 1993.

An even more telling point can be made from review of Federal Crop Insurance Corporation data on causes of loss associated with insurance payments for 1993. More than 80 percent of the insurance payouts, region wide, for the declared disaster counties were for causes of loss other than "flooding." Far more payouts were attributable to "excessive rainfall" than to any other cause of loss. St. Louis District counties along the Mississippi River and tributaries in Illinois and Missouri prove to be the primary exception, where approximately 62 percent of the losses were caused by overbank flooding associated with agricultural levees in the floodplain being overtopped in many locations. But agricultural losses in St. Louis District account for only 4 percent of the total regional agricultural losses. In the St. Paul District areas of Minnesota and Wisconsin, by contrast, only 1 percent of agricultural losses were attributable to "flooding," while 60 percent were caused by "excess rainfall." This area experienced more than 12 percent of the total regional agricultural losses. Causes of loss in Omaha, Kansas City, and Rock Island District areas fell between these two extremes. In Kansas City District, counties adjacent to the Missouri River also were subjected to flooding as the principal cause of agricultural losses. Nevertheless, in many locations, agricultural losses were not capable of being addressed by changes in floodplain management policies and programs, as these losses were experienced in upland areas of the watersheds, not in the floodplains themselves.

For the residential impact category, more than $760 million in damages are estimated to have been experienced across the region during the flood. St. Louis District counties alone contributed $431 million (57 percent) of this total. It appears that, in many locations, the estimates of flood damage exceed what might otherwise have been expected through application of existing stage-damage curves. It may be that these curves do not adequately cover the damages experienced when flood durations last several months. The extreme duration of the 1993 flood resulted in significantly greater damage than a comparable height flood of shorter duration.

Other urban damages, including losses to commercial and industrial structures, public buildings, transportation facilities, and utilities are estimated at more than $1.6 billion for the area examined by this assessment. Counties in the Kansas City District accounted for 40 percent of this total, and St. Louis District counties contributed another 37 percent. These reflect major impacts along the Missouri River as it crosses the State of Missouri and in the metropolitan Kansas City and St. Louis areas.

At least $227 million is estimated to have been spent on emergency response costs region-wide. St. Louis and Rock Island District counties were the locations of 45 percent and 31 percent of these expenditures, respectively.

At least $1.161 billion is estimated to have been expended on disaster relief for agriculture in the counties covered by this assessment. Omaha, Rock Island, and St. Paul District areas received the largest amounts of aid, reflecting the heaviest and most widespread losses in Iowa, Minnesota, South Dakota, and Missouri.

For disaster assistance related to human services, approximately $1.3 billion is estimated to have been expended in the counties examined for this assessment. Within four of the five Corps District boundaries, disaster assistance reached more than $250 million; the St. Louis District area, with a smaller number of counties, was the recipient of an estimated $134 million.

With respect to Federal insurance programs, expenditures through the National Flood Insurance Program (NFIP) and the Federal Crop Insurance Corporation (FCIC) were significantly less than the amount of disaster aid dollars provided for human resources and agricultural needs. For the NFIP, $372 million in claims payments is estimated to have been provided for the counties covered in this assessment. This number is larger than reported in the IFMRC Report (1994), but it reflects data collected 6 months later than the IFMRC effort and is thus, presumably, a more complete compilation. For the FCIC, approximately $748 million in claims payments were made in these same counties.

Critical Facilities

The Water Resources Council's Floodplain Management Guidelines established the concept of a "critical action." The report expressed concern that the impacts of floods on the safety of human health, physical safety, and welfare for public activities created a need for a greater amount of protection than that provided by 100-year base flood protection. Thus, a greater level of protection and a minimum basic standard used to evaluate critical actions were established with the 500-year level or 0.2 percent chance flood.

Along with the need for critical action evolves the need to determine the definition of a critical facility and its importance to the public. A suggested list of critical facilities has been determined by agency comments and coordination. "Critical" is defined as *'being in or approaching a state of crisis especially through economic disorders or by virtue of a disaster; characterized by risk or uncertainty.'* A "facility" is *'something that is built, installed, or established to serve a particular purpose.'* Therefore, a critical facility is a structure which is already built and located in the floodplain which cannot be moved due to the service it provides and which would cause a crisis or disaster to the lives and health of the community in which it is located if it were affected by a 500-year level flood (U.S. Water Resources Council, 1978).

The critical facilities determined to be hazardous to life and health can be identified by four major categories: 1) Hazardous Materials Production, Storage, and Waste Facilities; 2) Essential Utilities; 3) Essential Services; and 4) Emergency Services. The specific facility types in each major category are listed in Table 3-3.

Table 3-3. FPMA Critical Facility Category List.

1. Hazardous Materials Production, Storage, and Waste Facilities

- Superfund Sites
- Landfills
- Hazardous Waste Facilities
- Petrochemicals and Major Pipeline

2. Essential Utilities

- Municipal and Industrial National Pollutant Discharge Elimination System (NPDES) Sites
- Water Treatment Plants
- Major Water Supply Intakes
- Water Well Fields
- Sewage Treatment Plants
- Power Plants
- Major Power Utility Substations
- Communication Equipment and Related Antennas (television, radio, telephone services)

3. Essential Services

- Hospitals
- Group Homes for the Mobility Impaired
- Schools
- Major Airports
- Federal Post Offices
- State or Federal Bridges
- Prisons

4. Emergency Services

- Fire Departments
- Police Stations
- Military Bases
- Major Computer Centers

The first category, **Hazardous Materials Production, Storage, and Waste Facilities**, is defined as a plant or site which produces or stores toxic, volatile, or water-reactive materials for a period greater than 90 days and in sufficient amounts established by the Environmental Protection Agency (EPA) Guidelines. Hazardous Material Production, Storage, and Waste Facilities includes the collection, source separation, storage, transportation, processing, and treatment of hazardous wastes as listed by the Resource Conservation and Recovery Act of 1976, superfund sites established by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) for the treatment of inactive hazardous waste sites, landfills, hazardous waste facilities, petrochemicals, and major pipelines of petroleum and natural gas.

The second category, **Essential Utilities**, provides major service and aid to the essential welfare of a community. Essential Utilities are those which provide the unavoidable necessities of daily life. These facilities for essential utilities include water treatment plants, major water supply intake systems for large communities, water well fields, sewage treatment plants, power plants, major power utility substations/switching facilities, major power lines, municipal wells and substations, communication equipment and related antennas used in essential utilities such as television, radio, and telephone services who are members of the National Emergency Broadcast System. Municipal and industrial NPDES sites which have been specifically designated by permit to discharge pollutants into the waters of the United States were also included in this category.

Water supply intake systems for some small communities would be more cost efficient if the well or pipes were capped and drinking water was provided temporarily. These smaller communities would not be designated as "essential utilities" because of their size (and the option of bringing in drinking water for smaller communities). However, the loss of water is critical regardless of the population. The Safe Drinking Water Act applies the standard rules applicable to the initial building and rebuilding of water intake systems, regardless of the size of the community. Systems that would be inundated and suffer total water loss should be designated as Level I; these communities would have no water available to them at all. Level II is those communities which would have no potable water, but water sufficient for sanitary uses.

Essential Services, a third category, would include services which provide health care, transportation, and safety to society. These include hospitals, schools, group homes for the mobility impaired, major passenger airports, Federal post offices, bridges, and prisons. Housing for the elderly is considered a critical facility when fast and unexpected rising of floodwaters would prevent safe evacuation and placement of the elderly, who are relatively immobile (Federal Emergency Management Agency, 1987).

Airports are considered critical if they accommodate more than 1,000 passengers per day and are located in a floodplain. Essential bridges and highways which are critical include any State or Federal highway bridge across a major river (defined as having a drainage area of 4,000 square miles or more), interstate highway system, and Class I railroad bridges.

Emergency Services provide protection or assistance in the event of an emergency. The Emergency Services category would include fire departments, police stations, military bases, and computer centers which serve the previous emergency services.

Historical and cultural sites are not included in the definition of a critical facility, but deserve special attention. Protection of those structures and areas listed on the National Register of Historic Places is important in preserving the history of the country and the education of society (36 CFR 800).

A variety of sources were contacted in the attempt to identify and develop databases for these critical facilities. Some of this data had been compiled previously by the Federal Emergency Management Agency (FEMA), the Scientific Assessment Strategy Team (SAST), the Environmental Management Technical Center (EMTC), the Environmental Protection Agency, the Corps of Engineers, and a range of other State and Federal agencies and sources from the nine study area States. Usually data varied among sources in extent of coverage, degree of conversion to digital form, spatial characteristics or description, and overall availability. As part of the FPMA effort to identify critical facilities needing added protection, the compiled databases have been summarized in Table 3-4. A list of identified facilities and a general description of each is provided in Attachment 4, along with tables showing the quality, sources, and other characteristics of the data. It needs to be emphasized that the list of facilities is incomplete and is based on limited data that varies in quality from one location to another.

Risk Factors

Another challenge in examining existing floodplain resources and establishing an evaluation framework for this assessment was to include consideration of a range of social issues and impacts related to the 1993 flood. There were major societal disruptions associated with tens of thousands of people forced from their homes for extended periods; transportation disruptions with bridges closed and access to jobs and businesses severely impacted in river communities; and loss of at least 47 lives attributed to the flood. For this assessment, there was a need to establish impact categories that would serve as quantitative indicators of changes in impacts for which data could be obtained that would reflect social needs and conditions.

As a result, five impact categories were developed with the expectation that quantitative data and information could be obtained that would portray the severity of the 1993 flood. Two of the five impact categories related to critical facilities, as discussed in the previous section of this chapter. The other three involve estimates of the number of people that were vulnerable to flooding; the number of communities that were vulnerable to flooding; and the number of residential structures that were vulnerable to flooding. These risk related impact categories comprise rows 19 through 23 of the evaluation matrix summary tables, examples of which are initially presented in Chapter 4 of this report.

An obviously conservative method of estimating the number of people vulnerable to flooding, for which quantitative data was available, is to use the number of claims for assistance from agencies such as the FEMA individual and family assistance programs and Small Business Administration loan programs for homes, businesses, and economic injury. Based on employment, transportation, and public service disruptions in river communities that were flooded, it is also recognized that the impacts extended beyond those who incurred damages and losses to property. Data to account for such disruptions, in terms of number of people affected, were not able to be developed on a consistent basis for all affected areas in the entire basin, but would clearly include at least several million people.

TABLE 3-4. Number (1) of Critical Facilities Impacted by the 1993 Midwest Flood by District within the Floodplain Management Assessment Study Area (2).

	Corps of Engineer Districts					
Critical Facility	Omaha	Kansas City	St. Paul	Rock Island	St. Louis	TOTAL
Municipal & Industrial NPDES	9	18	-	-	-	27
Superfund Sites	-	-	2	-	-	2
Landfills	-	-	-	-	2	2
Hazardous Waste Facilities	-	1	-	9	51	61
PetroChemical and Major Pipeline	-	-	1	-	104	105
Water Treatment Plants	-	3	2	-	8	13
Major Water Supply Intakes	2	6	-	14	2	24
Water Well Fields	-	8	-	17	44	69
Sewage Treatment Plants	-	3	1	-	-	4
Power Plants	7	2	-	4	3	16
Hospitals	-	-	-	1	1	2
Group Homes	-	-	-	-	-	0
Schools	-	8	-	6	128	142
Federal and State Bridges	26	8	8	70	-	112
Prisons	-	2	-	-	2	4
Airports	3	8	1	6	3	21
Fire & Police Departments	-	2	-	-	23	25
Military Installations	-	3	-	-	-	3
Communications Facilities	-	1	-	-	-	-
Post Offices	-	13	-	-	-	-
TOTALS	47	86	15	127	371	632

(1) "-" indicates no impacted sites reported.

(2) This data set is based on available information, is not considered complete, and varies in quality from one location to another (See Tables in Attachment 4 for more information).

An estimate developed for this assessment is that more than 185,000 people were directly affected, based on damage to homes and property, by the Midwest Flood of 1993. St. Louis and Rock Island District counties had the most people affected.

An estimate of the number of communities flooded during the 1993 event was developed through a review of Corps of Engineers post-flood reports and other sources such as recipients of FEMA community infrastructure disaster assistance. Over 430 communities are estimated to have experienced flooding. Kansas City District reported more communities affected than any other District, with 229.

An estimate of the number of residential structures damaged or at severe risk from the 1993 event exceeds 56,000. Almost 42 percent of this estimate is for structures in the St. Louis District area.

Each of these estimates should be considered as an indication of the extent and severity of the Midwest Flood of 1993, but not as highly reliable, precise measurements. The estimates were developed for the primary purpose of having some quantitative information with which comparisons could be made of the change of impacts that could be expected if various changes in floodplain management policies, programs, or flood protection projects were made.

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Findings

3-a) Floodplains provide opportunities for a wide range of outputs that include both private individual and societal benefits.

3-b) Land use differences between the two river systems and between upper and lower reaches are apparent. Agricultural uses account for over 77 percent of the Missouri River floodplain and 31 to 64 percent of the Mississippi River floodplain, depending on the reach. Wetland and Forest account for a higher percentage of land use on the Mississippi River (15 to 25 percent) than on the Missouri River (10 percent).

3-c) Extreme floods rework alluvial deposits on the floodplain, which is a disturbance process that typically creates new habitats for early successional biota. Short-term adverse impacts may occur, but the long-term effect is generally beneficial.

3-d) A flood is the major way that exchanges of nutrients, organic matter, and organisms take place between the main channel and lateral floodplain areas. Thus, even though levees do prevent some environmental damages, they also break the linkage of floodplain ecosystem components.

3-e) The extreme 1993 flood inundated a large percentage of the floodplain and demonstrated how plants and animals, adapted to a flood-pulse (especially fish), respond positively to floods.

3-f) Expenditures for the 1993 flood through the National Flood Insurance Program and the Federal Crop Insurance Corporation were less than half of the disaster aid payments made for human resources and agricultural needs.

3-g) At least 50 percent of total 1993 flood damages were agricultural.

3-h) Based on 1993 Federal Crop Insurance Corporation payments, at least 80 percent of the agricultural damages region-wide were caused by saturated soil conditions, lack of drainage, or other causes, not overbank flooding, and most of this would not have been affected by changes in floodplain management policies or programs.

3-i) For the 120 counties adjacent to the Upper Mississippi and Lower Missouri Rivers and several of their major tributaries that were the focus of this assessment, urban damages substantially exceeded agricultural losses. Overbank flooding and problems associated with urban drainage and stormwater runoff continue to occur in a number of locations, as confirmed by the 1993 event.

3-j) Existing information and databases did not allow a comprehensive inventory of critical facilities subject to flood risk to be developed, nor to estimate costs to satisfactorily protect or relocate such facilities from flooding. A substantial amount of work remains to be accomplished to develop such information.

CHAPTER 4 - EVALUATION PROCESS

Introduction

As defined in the report, A Unified National Program for Floodplain Management 1994, floodplain management is "a continuous process of making decisions about whether and how floodplain lands and waters are to be used." It is broad in concept and inclusive as to the range of approaches that can be taken. The document identifies four strategies for managing floodplains that are directed toward the objectives of reducing risks both to human resources and natural resources. These strategies are:

* Modify human susceptibility to flood damage and disruption (i.e., avoid locations that are vulnerable to flood risk, or prepare for and accommodate the possibility of flooding);

* Modify the impact of flooding on individuals and the community (i.e., make flood insurance available for locations vulnerable to flooding or provide other kinds of assistance when flooding occurs);

* Modify flooding (i.e., construct projects to retain, divert, or protect against floodwaters); and

* Preserve and restore the natural resources and functions of floodplains.

An essential task in the conduct of this Floodplain Management Assessment (FPMA) was to evaluate a wide range of measures that might respond to the damages and other impacts to human and natural resources resulting from the 1993 flood. The floodplain management strategies identified above provide a context and suggest some tools by which flood impacts to humans might be reduced and floodplain resources sustained in the future. The measures need to include both: 1) policy and program changes that have the potential to affect the use of floodplains and thus exposure to flooding, and 2) actions that affect hydrologic and hydraulic conditions in the upper Mississippi and lower Missouri River Basins (i.e., the flood flows and stages). It was considered essential that a good balance and mix of nonstructural "measures" and structural "action alternatives" be evaluated, because each is among the approaches to be considered in developing more effective floodplain management strategies.

The BASE CONDITION against which the evaluations were compared is the 1993 flood, the 1993 floodplain land use, and the damages and other impacts that resulted from that event. The evaluations were conducted analyzing:

1) Scenarios (changes in policies/programs - generally "nonstructural" in character); and
2) Action alternatives that affect hydrologic and hydraulic conditions (generally "structural" in character).

The outcomes of the evaluations are described as "impact assessments." They are based on CHANGES in economic, environmental, and social/flood risk related impacts that could occur if measures comprising either a) the scenarios or b) the action alternatives were implemented, when compared to the 1993 flood base condition.

Two sample matrix tables (Tables 4-1 and 4-2) were used as worksheets for structuring the analysis. The first table displays the seven defined POLICY or PROGRAM issue areas within each SCENARIO (Columns C - I across the top). The economic, environmental, reduction of risk, and implementation cost IMPACT CATEGORIES are shown along the left edge of the table (Rows 1 - 25). Columns A and B are for display of the 1993 flood BASE CONDI-

TION impacts (the damages or other losses that were actually incurred). Column A includes all Federally declared disaster counties in the upper Mississippi River Basin, approximately 475 in number. Column B includes only those declared disaster counties, approximately 120 in number, that are adjacent to the main stem upper Mississippi and lower Missouri Rivers or to a limited number of reaches along several major tributary rivers. Most of the impact assessments that were completed are based on CHANGES (plus or minus) in impacts when compared to the Column B base conditions, although the Column A data is also useful for perspective on the extent of damages from the 1993 event basin-wide.

Three scenarios were developed as the means by which a wide range of "NONSTRUCTURAL" policy and program measures could be evaluated. Each scenario has its own completed summary impacts table presented at the conclusion of Chapter 7. Scenarios and the individual policy and program measures which comprise them are discussed in more detail and listed in Chapter 6.

The second sample table displays each ACTION ALTERNATIVE that is to be evaluated across the top (Columns K - W). These are actions that could affect the hydrology and hydraulics of flooding. They are NOT a part of the scenarios as described above. The same impact categories are shown in the left edge of the table (Rows 1 - 25). It is essential that the scenario measures and the action alternatives be examined from the same frame of reference provided by the impact categories. The same base conditions (Columns A and B) are used to provide an identical base line from which to compare changes in impacts for the action alternatives, the same process as described above for the scenario measures.

The letters and numbers on the top and left side of these sample tables have been used to cross-reference "cell note" descriptions in Chapter 3 of the Evaluation Appendix (Appendix B), where the most detailed discussion of scenario measures is presented. The intersections of column letters and row numbers make up individual "CELLS" in the tables. CELL C9, for instance, should identify how the measures examined under the National Flood Insurance Program regulations for Scenarios 1, 2, or 3 could have changed (increased or decreased) the amount of flood insurance payouts made after the 1993 flood event. CELL N3, as another example, should identify how the establishment of a uniform 25-year height for all agricultural levees could have changed (increased or decreased) the crop losses that were experienced when compared with the actual 1993 crop losses.

The evaluation framework, as represented by the two sample matrix tables, proved to be very useful in identifying a wide range of issues that need to be examined when changes in the policy/program scenario measures or the action alternatives are considered. The matrix tables assisted in structuring a consistent analysis for many floodplain management issues and in focusing research and data collection to answer specific questions.

As the evaluation proceeded, it became clear that, for many individual cells, data was not available or obtainable that would help establish what specific changes in impacts could be expected if the various scenario measures or action alternatives were to be implemented. In a number of instances, however, the connections between scenario measures or action alternatives with changes in impacts of potentially greatest significance were able to be better understood.

Clearly, a great deal more research and data collection would be required to fully evaluate the many important floodplain management issues that arise from this evaluation framework. This assessment represents only a start.

More details of the components of the evaluation framework and process are provided in the sections which follow.

TABLE 4-1
EVALUATION TABLE – SCENARIO CATEGORIES
(FLOODPLAIN SCENARIO ______)

	IMPACT CATEGORIES	A Base Cond [All Disaster Counties]	B Base Cond [Floodpln. Impacts]	C National Flood Ins. Program Regs.	D State Fldpln. Mgmt & Zoning	E Local Fldpln. Mgmt & Zoning	F Relocation, Mitigation Programs	G Disaster Relief Programs	H Floodplain Wetland Restor. Prog	I Agricultural Support Policies	J Signif. Findings
	ECONOMIC ($000's)		[1]								
	Flood Damages										
1	Residential (Urban)										
2	Other (Urban)										
3	Agricultural										
4	Other Rural										
	Chg. in Govt.Expend.										
5	Emergen.Resp.Costs										
6	Disaster Relief (Agric.)										
7	Disaster Relief (Human R.)										
8	Flood Insurance (NFIP)										
9	Flood Insurance (FCIC)										
	Chg.Value of FP Resources										
10	Net Ag RE Values										
11	Net Urban RE Values										
	ENVIRONMENTAL										
	Natur.Resour.(# acres)										
12	Non-Forested Wetl. (acres)										
13	Threat.&Endang. (# / Occ.)										
14	Forest (acres)										
	Natural Fldpln.Functions										
15	Fldpln.inundated (acres)										
	Cultural										
16	Archeol Impacts (-5 to +5)										
16A	Hist.Sites(-5 to +5)										
	Open Space										
17	Public lands (acres)										
18	Recreation sites (#)										
	REDUCT.OF RISK										
	Critical Facilities										
19	# Facil. w/harmful releases										
20	# other critical facilities										
	Prot./Avoid. of Harm										
21	# people vulnerable										
	Social Well Being										
22	# communities vulnerable										
23	# resident.struct.vulnerable										
	IMPLEMENT. COSTS										
24	Structural Costs										
25	Other Costs										

[1] Economic impacts collected only at the county level

File:scenfea2

TABLE 4-2
EVALUATION TABLE – SUMMARY OF ACTION ALTERNATIVES

		A	B	K	L	M	N	O	P	Q	R	S	T	U	V	W
				ACTION ALTERNATIVES AFFECTING HYDRAULIC CONDITIONS												
		Base Cond	Base Cond	AGRICULTURAL LEVEES					URBAN	CRITICAL FACILITIES		UPLAND RETENTION/WATERSHED MEASURES				
	IMPACT CATEGORIES	[All Disast Counties]	[Floodpln Impacts]	Limited Fld Fighting	Remove	Set Back [Varied]	Uniform Ht [25-YR.]	Raise	LEVEES [500-Yr.]	[500-Yr.] [Priority]	[500-Yr.] [All]	Without Reservoirs	Added Reservoirs	Revised Operation	Runoff Red [Decr. 5%]	Runoff Red [Decr. 10%]
	ECONOMIC ($000's)		[1]													
	Flood Damages															
1	Residential (Urban)															
2	Other (Urban)															
3	Agricultural															
4	Other Rural															
	Chg. in Govt.Expend.															
5	Emergen.Resp.Costs															
6	Disaster Relief (Agric.)															
7	Disaster Relief (Human R.)															
8	Flood Insurance (NFIP)															
9	Flood Insurance (FCIC)															
	Chg.Value of FP Resources															
10	Net Ag RE Values															
11	Net Urban RE Values															
	ENVIRONMENTAL															
	Natur.Resour.(# acres)															
12	Non-Forested Wetl. (acres)															
13	Threat.&Endang. (# / Occ.)															
14	Forest (acres)															
	Natural Fldpln.Functions															
15	Fldpln.inundated (acres)															
	Cultural															
16	Archeol Impacts (-5 to +5)															
16A	Hist.Sites(-5 to +5)															
	Open Space															
17	Public lands (acres)															
18	Recreation sites (#)															
	REDUCT.OF RISK															
	Critical Facilities															
19	# Facil. w/harmful releases															
20	# other critical facilities															
	Prot./Avoid. of Harm															
21	# people vulnerable															
	Social Well Being															
22	# communities vulnerable															
23	# resident.struct.vulnerable															
	IMPLEMENT. COSTS															
24	Structural Costs															
25	Other Costs															

[1] Economic impacts collected only at the county level

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Impact Categories

The impact categories were applied in the evaluation of all the alternatives being examined in the FPMA. THEY SERVE AS TARGETS TO FOCUS FLOODPLAIN RELATED DATA COLLECTION AND THE MEASUREMENT OR ESTIMATES OF POTENTIAL IMPACTS that result from implementation of the alternatives. For some impact categories such as Natural Resources, land use is the indicator of changes (impacts) in floodplain outputs. For other impact categories such as Flood Disaster Relief, dollars expended as a result of the 1993 flood event is the indicator of changes (impacts) in the floodplain outputs.

The basis for estimating changes in impacts is to compare, for each impact category, the 1993 land use (wetlands, open space, etc.) or flood impacts (floodplain related damages, losses, etc.) with what would have existed/occurred in 1993 if any given alternative (Scenario Measure or Action Alternative) had been in place at the time of the flooding. It is this estimate of incremental change in each of the impact categories that is the focus of the analysis for each alternative.

The definitions of the impacts being used to evaluate changes from one alternative to another, when compared against the 1993 base condition, are provided below.

ECONOMIC

Flood Damages

1) URBAN RESIDENTIAL: The change in estimated damages due to overbank flooding (i.e., within the floodplain) to structures used for housing and their contents, as measured in dollars.

2) OTHER URBAN: The change in estimated damages to all other structures due to overbank flooding, including commercial and industrial, public facilities, transportation facilities, and utilities, as measured in dollars.

3) AGRICULTURAL: The change in estimated damages to agricultural crops due to overbank flooding, as measured in dollars.

4) OTHER RURAL: The change in estimated damages to farm and other rural buildings and land losses, as measured in dollars.

Change in Government Expenditures

5) EMERGENCY RESPONSE COSTS: The change in estimated costs at all levels of government in preparing for and responding to an extreme flood event (e.g., the 1993 event) as it occurs, as measured in dollars.

6) DISASTER RELIEF (Agricultural): The change in estimated costs at all levels of government (and private relief agencies) in providing aid for agricultural losses after an extreme flood event, as measured in dollars.

7) DISASTER RELIEF (Human Relations): The change in estimated costs at all levels of government (and the private relief agencies) in providing aid to individuals, businesses, and communities for recovery after an extreme flood event, as measured in dollars.

8) FLOOD INSURANCE (NATIONAL FLOOD INSURANCE PROGRAM (NFIP)): The change in estimated costs of the Federal Government in making whole the flood insurance funds in cases where the claims paid exceed the premiums received from policyholders, as measured in dollars. For this assessment, total NFIP payouts were used as the 1993 flood base condition; the "net increase" cost to the Government for sustaining the fund was not identified.

9) FLOOD INSURANCE (FEDERAL CROP INSURANCE CORPORATION (FCIC)): The change in estimated costs of the Federal Government in making whole the crop insurance funds in cases where the claims paid exceed the premiums received from policyholders, as measured in dollars. For this assessment, total FCIC payouts were used as the 1993 flood base condition; the

"net increase" cost to the Government for sustaining the fund was not identified.

Change in Value of Floodplain Resources

10) NET AGRICULTURAL REAL ESTATE VALUES: The net change in the values of real estate used for agriculture, as measured in dollars.

11) NET URBAN REAL ESTATE VALUES: The change in values of urban real estate resulting from alternative use of undeveloped urban floodplains, as measured in dollars.

ENVIRONMENTAL

Floods in modified floodplain-river systems can have negative effects on the environment because of changes in amplitude or timing. However, floods are the major driving variable that allows exchanges of nutrients, organic matter, and organisms between floodplains and rivers; floods, consequently, do not typically have negative impacts on the natural environment. Although there are many known functions and values of floodplains that would be extremely valuable to measure and evaluate quantitatively, many of these would require detailed inventory and in some cases basic research that is beyond the scope of this assessment. To reduce the number of potential environmental variables to a reasonable but representative set, the FPMA considered land use as the main base condition and impact variable. Four general areas of environmental variables were used to assess the impacts of structural and nonstructural floodplain management activities relative to the 1993 flood: natural resources, cultural resources, natural floodplain functions, and open space.

Natural Resources

12) NON-FORESTED WETLANDS: Acres of non-forested wetlands in the floodplain including emergent and shrub/scrub wetlands (determined from National Wetlands Inventory data or as classified from Landsat imagery). Forested wetlands are captured in the "forest" category.

13) THREATENED AND ENDANGERED SPECIES: The number of species and the number of occurrences including both Federal and State listings. Occurrence is defined in accordance with the State Natural Heritage databases.

14) FOREST: Acreage of riparian and upland forest lands within each study reach. Forested wetland and upland forest were combined because the databases used to provide this information did not consistently differentiate between these forest types.

Natural Floodplain Functions

As discussed in Chapter 3, natural floodplains provide a wide variety of functions and related outputs. Many of these functions are not easily quantifiable, especially at the scale and detail under consideration by the FPMA. They are also not fully taken into account simply by considering acres of "natural" resources, because the hydroperiod of the floodplain, which includes its duration, intensity, and timing, is the ultimate determinant of the river-floodplain ecosystems structure and function. Wetland areas located behind levees, for example, are disconnected from the flood pulse and the lateral linkage between floodplain and river. However, wetlands landward of a levee can receive water from other sources, such as bluff toe seeps, highwater table, or overland drainage. In some cases, old oxbow lakes, in fact, are believed to be best left disconnected because of negative impacts of sediment deposition and increases in turbidity. To take into account the areas that may be affected by changes in the flood pulse, the total acres of inundated floodplain were determined to provide an index to the amount of "connection" between the floodplain and the river. It is assumed that the greater the amount of floodplain inundated, the more likely that natural processes are taking place (e.g., organic matter import/export, fish spawning in backwaters, natural sediment transport, etc.).

15) FLOODPLAIN INUNDATED: The change in the acreage of the total floodplain subject to overbank flooding.

Cultural Resources

These categories include impacts on archeological and historic sites, including those listed on the National Register of Historic Places and those not listed. Because a systemic database of known historic and archeological sites was not available, the base condition and changes from the base were measured as an index on a scale of -5 to +5. Three categories of effects on cultural resources were measured: 1) the effect of the 1993 flood; 2) the effect if various programs, policies, and action alternatives had been in place at the time of the 1993 flood; and 3) the effect of implementation. In the Cultural Resources Impact Matrix Cells, the first number represents the change from the base condition of a similar magnitude flood following implementation of the policy or alternative, and the second number (in parentheses) reflects implementation effects.

16) ARCHEOLOGICAL IMPACTS: The degree and nature of the potential impacts will be described rated on a scale of -5 to +5.

16A) HISTORICAL SITES: The degree and nature of the potential impacts will be described rated on a scale of -5 to +5.

Open Space

17) PUBLIC LANDS: Public land included under the category of "Open Space" includes wildlife management areas, wildlife refuges, natural areas, State and national forests and the like. The base area presented includes the entire unit, even if only a portion of the unit falls within the study boundary.

18) RECREATION SITES: The number of sites designated primarily for recreational use. This includes the number of Federal, State, and local parks, and public use areas. State and national forests have been included because they provide significant recreational opportunities.

REDUCTION OF RISK

Critical Facilities

19) NUMBER OF FACILITIES WITH HAZARDOUS MATERIALS AT RISK: The change in the number of facilities dealing with hazardous or toxic materials that could immediately harm people or the environment if exposed to flooding. These facilities or sites include:

i. Superfund sites
ii. Landfills
iii. Hazardous waste facilities
iv. Petrochemical plants and major pipelines

20) NUMBER OF OTHER CRITICAL FACILITIES AT RISK: The change in the number of other facilities providing essential public services that are potentially exposed to flooding. These facilities and sites include:

i. Sewage treatment plants
ii. Power plants
iii. Water treatment plants, water well fields, and major water supply intakes
iv. Municipal and industrial NPDES (National Pollutant Discharge Elimination System) sites
v. Major power utility substations
vi. Communications equipment and related antennas (television, radio, and telephone services)
vii. Hospitals and group homes for mobility impaired
viii. Public service buildings (i.e., schools, post offices, police stations, and fire departments)
ix. Prisons
x. Major airports
xi. State or Federal bridges
xii. Military bases

Protection of or Avoidance of Harm to People

21) NUMBER OF PEOPLE AT RISK: The change in the estimated number of people who

are vulnerable to flooding in the upper Mississippi and lower Missouri River Basins.

Social Well-Being

22) NUMBER OF COMMUNITIES AT RISK: The change in the estimated number of communities that are vulnerable to flooding in the upper Mississippi River and lower Missouri River Basins.

23) NUMBER OF RESIDENTIAL STRUCTURES AT RISK: The change in the estimated number of residential structures that are vulnerable to flooding in the upper Mississippi River and lower Missouri River Basins.

IMPLEMENTATION COSTS

24) STRUCTURAL COSTS: Estimate of costs directly related to the construction of the flood control feature, including real estate for the structure itself, but not other real estate costs.

25) OTHER COSTS: Estimates of costs to implement the alternatives, not including the structural costs, such as acquiring interests in real estate affected or agency administrative costs.

Floodplain Policy and Program Changes (Scenarios)

Scenario measures (policy and program changes) are in many cases quite difficult to evaluate. They require judgments to be made concerning the behavioral responses that might be linked to changes in such programs as flood insurance, zoning practices, disaster relief and flood hazard mitigation, or agricultural incentives. Databases are not often available at a level of detail that would be needed to make estimates of possible changes in impacts with a high degree of confidence. In some cases, the right research questions remain to be asked before reasonable answers can be obtained.

Although several concepts for projecting changed conditions, either from the past to the present or from the present into the future, were discussed, the approach that was applied involves estimating the environmental, economic, and social impacts that could have resulted had the revisions to the policies and programs been in effect at the time of the 1993 flood. This provides some degree of familiarity, given the widespread firsthand experience with the 1993 flood. It also maintains consistency with the hydraulic modeling rationale, which is based on a UNET model calibrated to the 1993 flood and provides the means by which the impact assessments of the action alternatives were completed.

Combining a number of these policy and program changes into a package of measures constitutes a "SCENARIO." Scenarios serve several purposes. They offer contrasting visions, showing where alternative floodplain management philosophies could lead. Policy/program measures considered in this assessment range from relatively modest changes to the status quo to substantially greater efforts to enhance the natural resource attributes of floodplains while emphasizing avoidance of flood risks. Three scenario "packages" were devised in an attempt to lend some coherence to a series of policy and program proposals that in tandem could result in significant changes to the status quo.

Each of the three scenarios contains at least one measure from each of the seven policy and program categories. The scenarios are LIMITED in several ways, however, which are important to understand. The scenarios DO NOT comprise a uniform series of measures from one scenario to another. Therefore, it is inappropriate to attempt to compare scenario impacts one to another. A scenario is merely the label or shell under which individual measures in the seven policy and program categories have been placed. It is much more important to examine the impacts of the individual measures which comprise the scenarios.

Scenarios DO NOT contain the action alternatives. Action alternatives are evaluated separately based on use of the systemic UNET model.

An unlimited number of scenarios could be devised based on the countless combinations of 45 measures that have been identified for consideration, as discussed in Chapter 6. Scenarios do not constitute implementable plans, nor has an attempt been made to "optimize" or otherwise develop one "best" scenario. Neither has analysis of the synergistic effects of combining measures within a scenario, or across scenarios, been accomplished. The evaluation framework encourages further thought and research along these lines, perhaps, but taking this step went beyond what could be accomplished by this assessment.

A substantial amount of work has been completed in reviewing individual measures within the seven policy and program categories which comprise the scenarios. Chapter 7 of this report and Chapter 3 of the Evaluation Appendix (Appendix B) present the research and analysis related to these measures. The outcome of these evaluations, and findings which have been developed, are based on impact assessments of the measures and the policy/program categories themselves, and are NOT closely related to any of the scenarios.

Action Alternatives Affecting Hydrologic and Hydraulic Conditions

For actions such as changes in levee configurations, reservoir operations, and other watershed retention and management measures, hydraulic modeling has been completed, using the 1993 event, to develop and compare a range of water flow and stage conditions in the rivers. These conditions were analyzed for potential environmental, economic, and social impacts. For a limited number of actions, systemic UNET modeling of the entire river network was accomplished. These include agricultural levee removal; setbacks; uniform 25-year height; raises to contain the 1993 flood; no reservoirs; and 5 and 10 percent runoff reductions. For other actions, modeling was completed to allow analysis of potential impacts for specified reaches ("impact reaches") of the rivers. Modeling the 1993 event was defined by the actual levee height, including flood fight efforts and levee breaches.

The 1993 flood event varied in likelihood of recurrence along the lower Missouri and upper Mississippi Rivers. Using the 1993 flood event allowed assessment of both large and small events within the study area. It is expected that the hydraulics and hydrology models developed as a part of this effort will be useful in other applications for future analysis.

Application of the UNET model in analyzing the hydrology and hydraulics of the action alternatives is discussed in Chapter 8 and in Appendix A. Impact assessments of the action alternatives are presented in Chapter 9.

Summary of Evaluation Process

The above description of the evaluation framework can be summarized in stating that three primary components are being used to quantify, where possible, the relative impacts of a wide array of alternative floodplain management philosophies and flood control measures. The three components are **policy and program scenario measures; action alternatives; and assessment of impacts**.

Impacts are being evaluated assuming: 1) changes in the policy and program measures comprising the three scenarios had been in place at the time of the 1993 flood; and 2) separately assuming various action alternatives (such as all agricultural levees removed) had been in place at the time of the 1993 flood. Initially, it was thought that packaging policy and program measures together would enable the FPMA team to consider combinations of hydraulic related actions and floodplain policy related changes. This assessment developed an evaluation framework that should assist in making such an evaluation process possible. However, it did not take the analysis to the point of comparing combinations of multiple action alternatives or combined action alternatives with changes in policy and program measures.

An essential point highlighted by the evaluation framework and process is that responding to floodplain management issues needs to include consideration of SYSTEMIC as well as localized effects, whether through policy and program changes or by actions affecting hydrologic and hydraulic characteristics within the upper Mississippi/lower Missouri River Basins.

CHAPTER 5 - ESTABLISHING BASE CONDITIONS FOR EVALUATION

Introduction

This chapter presents the 1993 flood base condition information and data, for each of the five Corps District offices, that have been developed and used as part of the evaluation process completed for this assessment. This data has been summarized for the impact and resource categories established in the evaluation framework matrix table via "cell" entries shown in Columns A and B. Column A covers all Federally declared disaster counties within the upper Mississippi and lower Missouri River Basins. Column B covers the roughly 120 counties that are adjacent to the main stem rivers and several of their major tributaries. The base condition values for Columns A and B for the five-District basin area are shown in Table 5-1.

Summary tables showing base conditions and action alternative impacts for each of the five Districts are located at the end of Chapter 9. They follow the analyses of the action alternatives that are presented in that chapter.

Highlights of existing floodplain resources and base condition impacts from the regional perspective were introduced in Chapter 3 of this report. This chapter will present in more detail the significant impacts from each District for the 1993 flood that were important in establishing a base condition for this assessment.

Aside from flood damages experienced by transportation facilities, this assessment did not examine the disruption losses experienced by the barge industry or other transportation modes. Locks on the upper Mississippi River from Lock and Dam 3 to Lock and Dam 27 all were closed at some point during the summer flood event. Lock and Dam 24 was closed for 55 consecutive days from June 29 to August 22. Summaries of the flood event as it pertains to navigation are included in the Corps of Engineers Main Report of The Great Flood of 1993 Post Flood Report, and in the Economic Damage Data Collection Report prepared by the Lower Mississippi Valley Division (LMVD). The Galloway Report cited Maritime Administration estimates of revenue losses at $300 million per month during the period of lock closures.

Omaha District Base Conditions

Omaha District includes 112 counties in the six States of North Dakota, South Dakota, Nebraska, Minnesota, Iowa, and Missouri, that were presidentially-declared flood disaster counties in 1993. These counties make up the overall base for evaluating flood impacts.

The Missouri River basin contains numerous reservoirs and impoundments constructed by different interests for flood control, irrigation, power production, recreation, and water supply. The most significant of these structures have been constructed by the Corps of Engineers and the Bureau of Reclamation. Although constructed primarily for irrigation and power production, the projects constructed by the Bureau provide some limited flood control in the upper basin. The most significant flood control projects constructed within the basin are the six main stem Missouri River dams constructed by the Corps. The six dams, completed by 1964, provide flood protection by controlling runoff from the uppermost 279,000 square miles of the Missouri River Basin. The system has a total combined capacity in excess of 73 million acre-feet, of which more than 16 million acre-feet is for flood control. Gavins Point Dam, located near Yankton, South Dakota, is the most downstream of the projects.

For the purposes of the Floodplain Management Assessment (FPMA), modeling efforts were confined to the reach from Gavins Point Dam to Rulo, Nebraska, within the Omaha District. Of the 25 counties contingent to the Missouri River below the Gavins Point Dam and above the

Table 5-1. Base Conditions for FPMA study area.

	IMPACT CATEGORIES	A Base Cond. [All Disast. Counties]	B Base Cond. [FPMA Imp. Counties]	C National Flood Ins. Program Regs.	D State Fldpln. Mgmt & Zoning	E Local Fldpln. Mgmt & Zoning	F Relocation, Mitigation Programs	G Disaster Relief Programs	H Floodplain Wetland Restor. Prog	I Agricultural Support Policies	J Signif. Findings
	ECONOMIC ($000's)		[1]								
	Flood Damages										
1	Residential (Urban)	$760,892	$662,008								
2	Other (Urban)	$1,612,543	$1,447,322								
3	Agricultural	$3,852,701	$817,054								
4	Other Rural	$233,648	$161,010								
	Chg. in Govt.Expend.										
5	Emergen.Resp.Costs	$227,405	$200,663								
6	Disaster Relief (Agric.)	$1,160,632	$285,180								
7	Disaster Relief (Human R.)	$1,297,474	$551,862								
8	Flood Insurance (NFIP)	$371,969	$276,496								
9	Flood Insurance (FCIC)	$748,095	$269,061								
	Chg.Value of FP Resources										
10	Net Ag RE Values	–	–								
11	Net Urban RE Values	–	–								
	ENVIRONMENTAL										
	Natur.Resour.(# acres)										
12	Non-Forested Wetl. (acres)	–	365,285								
13	Threat.&Endang. (# / Occ.)	–	(281/1,043)								
14	Forest (acres)	–	534,705								
	Natural Fldpln.Functions										
15	Fldpln.inundated (acres)	–	2,685,281								
	Cultural										
16	Archeol Impacts (-5 to +5)	–	-1								
16A	Hist.Sites(-5 to +5)		-1								
	Open Space										
17	Public lands (acres)	–	392,512								
18	Recreation sites (#)	–	485								
	REDUCT.OF RISK										
	Critical Facilities										
19	# Facil. w/harmful releases	–	207								
20	# other critical facilities	–	1,208								
	Prot./Avoid. of Harm										
21	# people vulnerable	185,630	134,849								
	Social Well Being										
22	# communities vulnerable	433	293								
23	# resident.struct.vulnerable	56,339	42,743								
	IMPLEMENT. COSTS										
24	Structural Costs	–	–								
25	Other Costs	–	–								

[1] Economic impacts collected only at the county level

Omaha District boundary near Rulo, 19 were among the 1993 presidentially-declared flood disaster counties. These 19 counties are the Omaha District "impact counties." The base impacts to these counties make up the baseline against which hydraulic and hydrologic alternatives have been modeled. For purposes of this analysis, county-wide impact information for Holt County, Missouri, and Richardson County, Nebraska, has been allocated between Omaha and Kansas City Districts, with Omaha claiming 81 percent of Richardson County and 24 percent of Holt County. All other county impacts are addressed as county totals.

Missouri River Levee System - Omaha District

The Missouri River levee system was authorized by the Flood Control Acts of 1941 and 1944 to provide protection to agricultural lands and communities along the Missouri River from Sioux City, Iowa, to the mouth at St. Louis, Missouri. The levees were designed to operate in accord with the six main stem dams. The extent of the levee system within the Omaha District consists of intermittent levee units on both banks from near Omaha, Nebraska, to Rulo, Nebraska. There are no Federal levees from Gavins Point Dam to the Omaha, Nebraska-Council Bluffs, Iowa, area. Although many Federal levees were proposed on the reach north of Omaha, Nebraska, along the Missouri River, none have been built due to the significant protection provided to this reach by the Missouri River main stem dams. Degradation of the channel bottom, over time, has further reduced the necessity for levees in this reach. The majority of the area planned for protection by Federal levees, north of Omaha, Nebraska, is protected by private or non-Federal levees with varying degrees of protection.

The Federal levee system starts in Douglas County, Nebraska, protecting Omaha, and in Pottawattamie County, Iowa, protecting Council Bluffs. These urban levees were not threatened by the 1993 floods. Levees were constructed downstream of Omaha to Rulo, Nebraska, which protect agriculture and several very small towns. All of the levee units on the Missouri River were designed to operate in conjunction with the six main stem dams to reduce flood damages as part of the Pick-Sloan plan. Federal levees were constructed in the 1950's and are usually set back from the riverbank 500 to 1,500 feet. Federal levees cover the left bank from river mile (RM) 515.2 to RM 619.7. Levees on the right bank are intermittent since the river is often near the bluff. Total Federal levee length is estimated at 191 miles in the reach from Omaha, Nebraska (RM 615.9) to Rulo, Nebraska (RM 498.1). The 191 levee miles may be subdivided as 133.5 miles along the main stem Missouri River and 57.5 miles of levee tiebacks.

Following levee construction and chute closure, deposited sediment filled many areas riverward of the Federal levees. Farming of these areas became extensive. To prevent crop damages caused by normal high flows on the Missouri River, farmers constructed secondary levees at or near the riverbank. Many of the secondary private levees tie directly into the Federal levees. Private levees have also been constructed along the riverbank in areas where Federal levees were not constructed. The left bank reach from RM 515.5 to RM 498.1 near Rulo, Nebraska, is protected solely by private levees.

Overall, the federally constructed levees performed very well in the 1993 flooding. As a result of the extremely high flows, all Federal levees from unit L-575 downstream to unit R-520 experienced some overtopping either on the main stem or a tieback levee. Overtopping was generally over a short levee section with limited depth and duration. The design event of most Missouri River Federal levees was significantly exceeded during 1993. Within the Omaha to Rulo reach, a single Missouri River Federal agricultural levee, unit L-550, breached during the 1993 event.

Since construction of Federal flood control projects along the Missouri River, significant change has occurred in channel conveyance as a result of aggradation and degradation. Numerous studies have been conducted by the Omaha District to quantify Missouri River geometry changes. Results of these studies have determined a general upward shift of the stage-discharge relationship. For the period 1952 to 1989 and using a discharge of 100,000 cubic feet per second, the Missouri River Channel Capacity Study, August 1992, determined a stage rise of 2 feet at Omaha, Nebraska, a 3-foot rise at Nebraska City, Nebraska, and a 3-foot rise at Rulo, Nebraska. Comparison of rating curves illustrates a general upward rise at all discharges during the past 30 to 40 years.

The 1984 Missouri River flood event prompted a study to evaluate the adequacy of the Missouri River levee system from Omaha, Nebraska, to Rulo, Nebraska. The study investigated both the discharge-frequency and stage-discharge relationships on the Missouri River. Study results determined that the existing level of protection is much less than originally designed. With 2 feet of freeboard, several Federal levees now provide less than a 50-year level of protection. The present level of protection provided by these levees is unknown.

In spring 1995, Omaha District surveyed floodplain cross sections on both the left and right banks at three separate locations. Cross sections were surveyed along the alignment of cross sections which had been previously surveyed in the 1970's. The purpose of the survey was to compare elevations in the current condition with the previous condition. Comparison showed a general aggradational trend in the floodplain which varied from 1 to 3 feet. Although no computations were performed to quantify the effect on flow, the comparison indicates that further rises in the stage-discharge rating curve have occurred in the past 20 years.

Critical Facility Investigation

Accurately defining the level of protection of any critical facility along the Missouri River would require a detailed risk assessment employing hydrologic, geotechnical, and other components. An evaluation of this extent was not conducted for any critical facility site within the Omaha District. A brief investigation was conducted of the current level of protection and access concerning the Cooper Nuclear power plant. The Cooper Nuclear power plant is located on the right bank of the Missouri River at approximately RM 532.4 which is 2.8 river miles downstream of the Brownville bridge. On the weekend of July 24, 1993, a record crest of the Missouri River overtopped a levee 2.5 miles north of the U.S. Highway 136 Brownville bridge. Access to the area was limited, as many local roads, State highways, and Interstate 29 all were closed for periods of several days.

Federal levee unit R-548 is located on the right bank of the Missouri River between RM 528 and RM 534 and protects the Cooper Nuclear power plant area. The upstream tieback extends to high ground south of Brownville and the downstream tieback extends up the Little Nemaha River and minor tributaries. In 1984, peak stages were within 3 to 4 feet of the levee top. In July 1993, overtopping occurred along the tieback levees. The technical summary report Adequacy of Missouri Levee System, prepared by Omaha District Engineering Division, April 1986, identified the level of protection for the R-548 levee unit as 20- to 50-year protection with 2 feet of freeboard. Several other Federal levees between Omaha and Rulo also have less than a 100-year level of protection, which may have an impact on critical facilities in these areas.

The base facility elevation at the Cooper Nuclear power plant is 903.5. This elevation is approximately 1 foot above the adjacent Federal levee and 2.5 feet above the peak stage for the 1993 event. Peak stage was reduced at the Cooper Nuclear site as a result of the L-550 levee breach which occurred on the opposite bank of the Missouri River approximately 4 miles upstream. Flood frequency for the 1993 event at the Cooper Nuclear site was estimated as a 50- to 100-year event.

The 1993 event generated several concerns with regard to Cooper Nuclear power plant safety. Access to the plant during floods is a function of the R-548 levee unit integrity. The 1993 event demonstrated that access to the Cooper Nuclear site is not possible during major flood events, as much of the interior R-548 levee area had ponding which inundated access roads. If levee failure occurs, ponding depths within the R-548 levee unit are determined by river stage and levee breaching parameters. Effects such as levee breaching at an upstream location and wind/wave run-up could cause additional increases in ponding elevations. The 1993 event and the levee adequacy study conducted by Omaha District both demonstrated that the R-548 levee provides less than a 100-year level of protection. The 1993 event indicates that further investigation of protection provided by Federal levees and their tiebacks to critical facilities and especially to the Cooper Nuclear power plant below Brownville, Nebraska, is warranted.

Omaha District Evaluation Methodology

In all cases, unless noted, economic impacts are based on county totals. Environmental impacts are for resources within the floodplain only. Baseline economic damages are based largely on the Corps of Engineers Post Flood Data Collection database.

Plate 5-1 shows the overbank flooding area taken from aerial photographs. The brown area is the main channel and areas where the levees failed. The yellow areas are where there was ponding behind the levees as well as overtopping but nonfailure. The tan areas are where the levees did not overtop but there was still considerable crop damage due to interior ponding.

The residential, commercial, industrial, and institutional structure damages for the overbank flooding for the base and for each alternative were obtained from existing land use data, UNET modeled stages, existing Omaha stage damage curves for activity types, and the Omaha District Damage Model. Agricultural damages and changes in number of critical facilities impacted from the overbank were obtained using UNET generated flood area boundaries and Geographic Information System (GIS) generated Missouri River Basin Atlas land use. An example of the level of detail available from the Missouri River Basin Atlas is shown on plate 5-2. The acreage totals for the listed types of land use for the overbank and interior ponding area and percentages of total are listed in table 5-2.

The numbers should be used as order of magnitude numbers for comparisons. The true agricultural loss, for example, could not be defined precisely without a more encompassing analysis of production investment and returns by area and of pricing and subsidy data.

Omaha District Baseline Economic Impacts

For the base of 112 counties, over $654 million in damages was estimated for agriculture and other rural. This makes up over 75 percent of the damages for Omaha District based on extrapolated data. There was nearly $502 million in disaster relief for agriculture from the Agricultural Stabilization and Conservation Service (ASCS) and the Farmers Home Administration (FmHA) and from Federal Crop Insurance Corporation (FCIC) crop insurance payouts. There are additional agriculture costs that were not tabulated. An example is any loss in land value due to increased perception that land is vulnerable to flooding.

It is estimated that over 12,500 people, 4,320 residences, and 12 communities experienced flooding. The estimates in these categories are probably quite low.

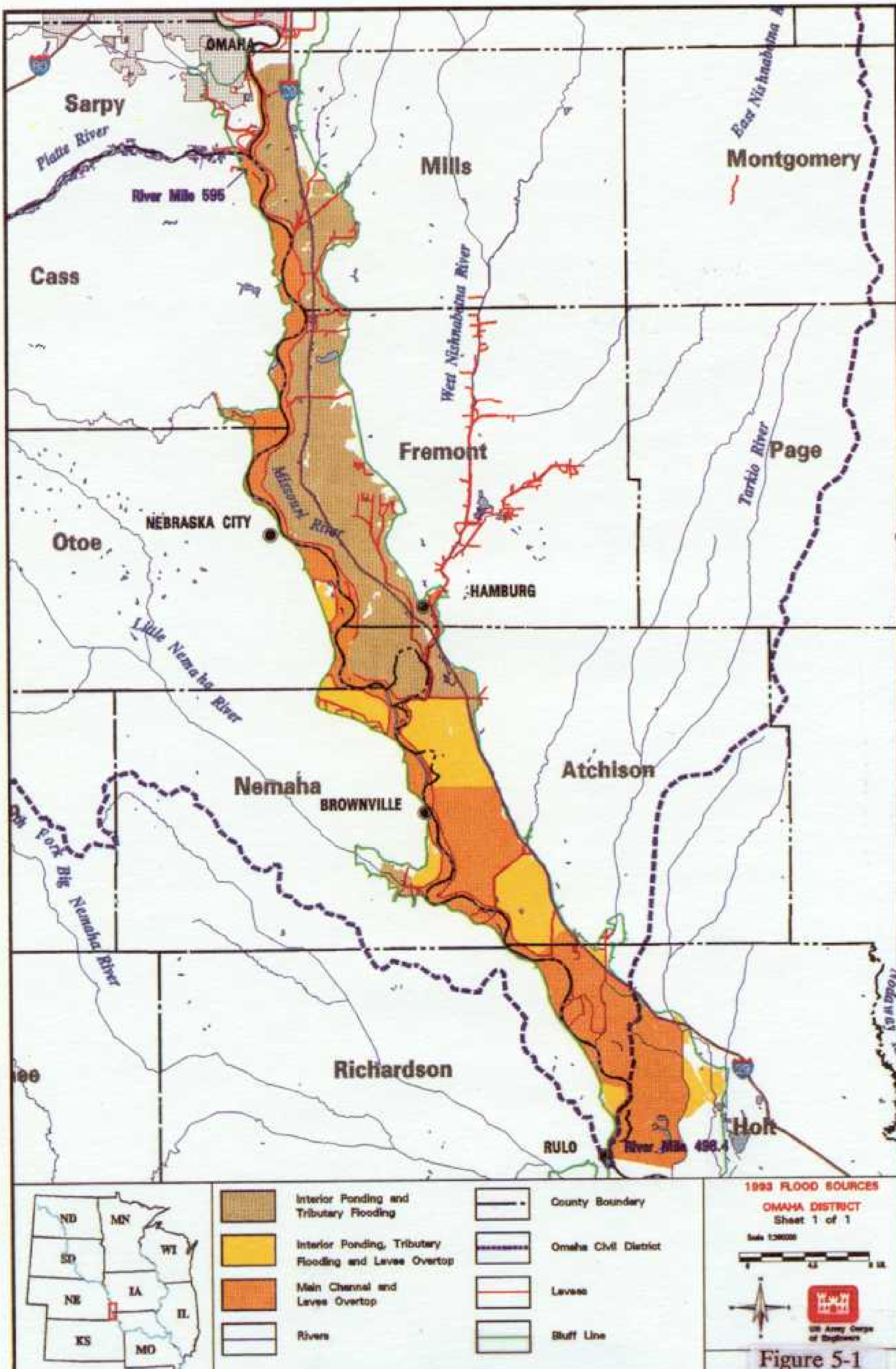

OMAHA
Sarpy
Platte River
River Mile 595
Mills
Montgomery
East Nishnabotna R
Cass
West Nishnabotna River
Fremont
Page
Tarkio River
Missouri River
NEBRASKA CITY
Otoe
HAMBURG
Little Nemaha River
Atchison
Nemaha
BROWNVILLE
Big Nemaha River
Richardson
Holt
RULO
River Mile 498.4
Nodaway R
ND
MN
SD
WI
NE
IA
IL
KS
MO
Interior Ponding and Tributary Flooding
Interior Ponding, Tributary Flooding and Levee Overtop
Main Channel and Levee Overtop
Rivers
County Boundary
Omaha Civil District
Levees
Bluff Line
1993 FLOOD SOURCES
OMAHA DISTRICT
Sheet 1 of 1
US Army Corps of Engineers

Figure 5-1

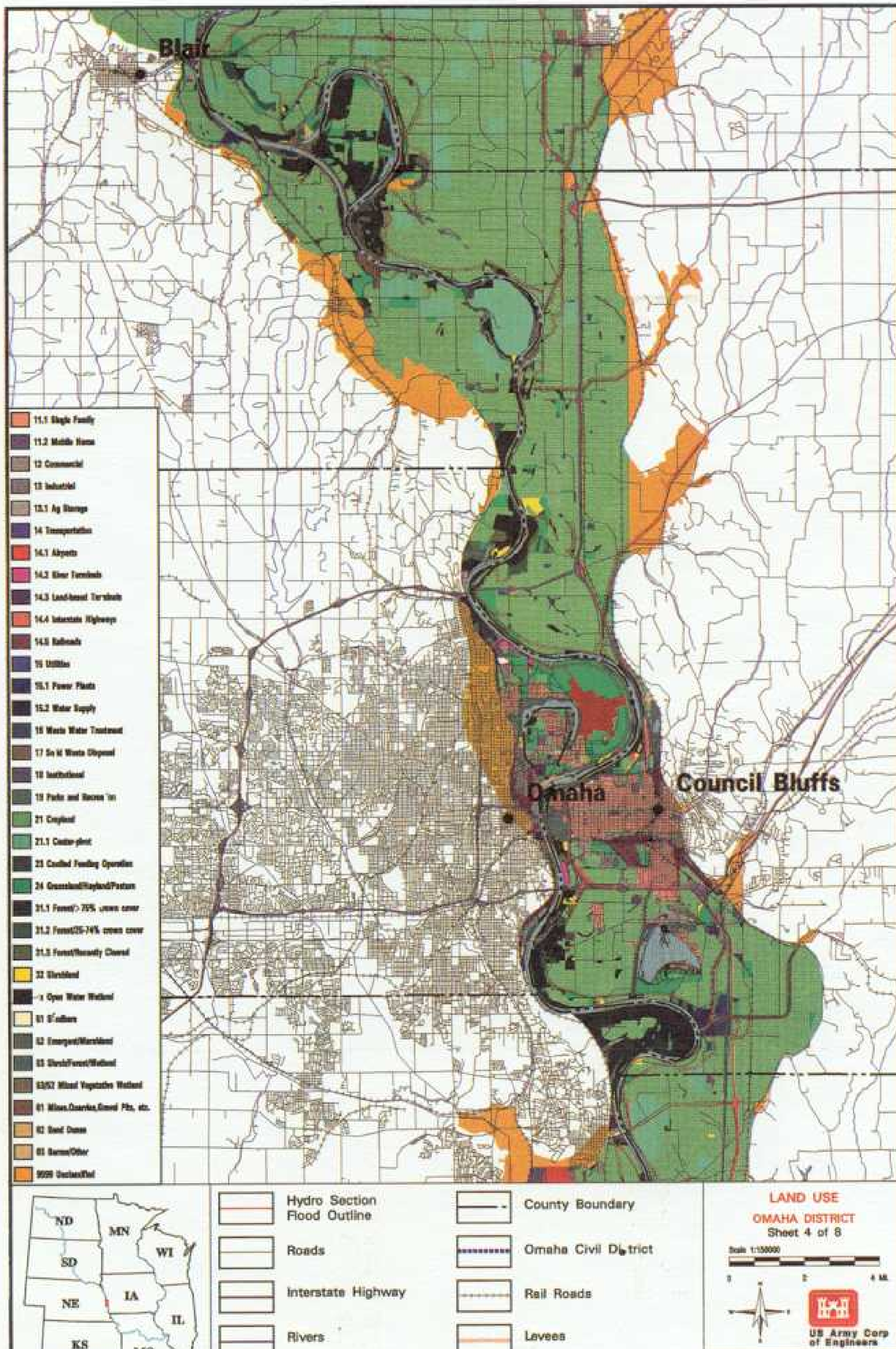

Blair
Omaha
Council Bluffs
ND
MN
SD
WI
NE
IA
IL
KS
MO
Hydro Section
Flood Outline
Roads
Interstate Highway
Rivers
County Boundary
Omaha Civil District
Rail Roads
Levees
LAND USE
OMAHA DISTRICT
Sheet 4 of 8
US Army Corp
of Engineers

Figure 5-2

Table 5-2

Land Use Flooded by Overbank and Interior Ponding in 1993
Missouri River, Omaha to Rulo

	Land Use Category	Acres	Percent
11.1	Residential Single Family	848	0.0
11.2	Residential Mobile Home		0.0
11.3	Residential Multi-family	-	0.0
12	Commercial	85	0.0
12.5	Mixed Commercial and Industrial	-	0.0
13	Industrial	62	0.0
13.1	Agricultural Storage	33	0.0
14.1	Airports	58	0.0
14.2	River Terminals	26	0.0
14.3	Land-based Terminals	14	0.0
14.4	Interstate Highways	532	0.2
14.5	Railroads		0.0
15.1	Power Plants	76	0.0
15.2	Water Supply	14	0.0
16	Wastewater Treatment	118	0.0
17	Solid Waste Disposal		0.0
18	Institutional	25	0.0
19	Parks and Recreation	232	0.1
21	Cropland	233,933	83.3
21.1	Center Pivot Irrigated Cropland	7,771	2.8
22	Specialty Crops		0.0
23	Confined Feeding Operations	81	0.0
24	Grassland/Hayland/Pasture	4,860	1.7
31.1	Over 75% Crown Cover Woodland	11,505	4.1
31.2	25% to 74% Crown Cover	1,469	0.5
31.3	Recently Cleared	1,178	0.4
32	Shrubland	167	0.1
41	Missouri River Main Channel	8,960	3.2
41.1	Mud Flats	-	0.0
42	Mo. R. Side Channels & Backwater	319	0.1
42.1	Mud Flats	-	0.0
43	Tributaries	372	0.1
44	Intermittent Streams	11	0.0
45	Lakes	1,420	0.5
45.1	Mud Flats		0.0
46	Ponds	941	0.3
46.1	Mud Flats	10	0.0
51	Sandbars	84	0.0
52	Emergent	2,592	0.9
53	Shrub/Forest	3,041	1.1
53.5	Mixed Vegetative Wetlands	-	0.0
61	Mines, Quarries, Gravel Pits, Etc	61	0.0
62	Sand Dunes	10	0.0
63	Other	46	0.0
	TOTAL	280,980	100.0

There was over $65 million in residential damage and another $124 million in other urban and infrastructure damage. Emergency costs, human resource related disaster assistance, and National Flood Insurance Program (NFIP) flood insurance payouts totaled over $305 million.

The 19 impact counties suffered over $125 million in damages estimated for agriculture and other rural. This makes up about 60 percent of the damages for these counties based on extrapolated data. There was nearly $94 million in disaster relief for agriculture from the ASCS and FmHA and from FCIC crop insurance payouts.

It is estimated that over 1,647 people, 553 residences, and 8 communities experienced flooding. There was over $24 million in residential damage and another $62 million in other urban and infrastructure damage. Emergency costs, human resource related disaster assistance, and NFIP flood insurance payouts totaled over $75 million.

Included in the base conditions was damage due to interior ponding, most tributary flooding, and agricultural damage due to excess precipitation. Figure 5-3 shows all the counties in Iowa and Missouri on the left bank that were presidentially declared disaster counties in 1993 and the proportion of FCIC payout caused by flooding compared to that caused by excess precipitation. Generally, because of the mainstem dams, all agricultural damage above Omaha was caused by excess precipitation or flooding on tributaries.

Omaha District Baseline Environmental Resources

Environmental base conditions in the Omaha District study area (Gavins Point Dam to Rulo, Nebraska) at the time of the 1993 flood are taken from the Environmental Resource Inventory (Appendix C). The following is a description of some of the significant and unique environmental resources.

The study area contains approximately 317 lakes and ponds, a majority of which are oxbow or cutoff lakes which offer significant habitat for migrating waterfowl, passerines, raptors, and shorebirds as well as important spawning, nursery, and feeding areas for fish if there is periodic access to the river. These lakes include: McCook Lake (RM 740), Crystal Lake (RM 735), Browns Lake (RM 717), Badger Lake (RM 703), Blue Lake (RM 693), Round Lake (RM 664), DeSoto Lake (RM 643), Lake Manawa (RM 607), Folosom Lake (known bald eagle nesting site) (RM 597), Forneys Lake (RM 577), Greys Lake (RM 545), and Big Lake (RM 500).

Public land in the Omaha District is scarce compared to other Mississippi River Basin Districts; therefore, all public land in the Omaha District is considered significant. Projects like Missouri River Mitigation and the Missouri River Corridor Study concentrate on land acquisition to restore riparian and stream habitat lost as a result of the Missouri River Bank Stabilization and Navigation Project.

Both the mitigation and the corridor study target areas with the greatest potential for habitat restoration. The corridor project emphasizes recreational opportunities, while the mitigation project emphasizes fish and wildlife management. A list of recommended restoration sites includes: Omadi Bend, Glovers Point, Blackbird State Wayside Area, Lower Bullard Bend, California Bend, Boyer Chute, Hidden Lake, Missouri River Trails, Louisville Bend, Winnebago Bend, Langdon Bend; Blackbird, Decatur, and Tieville Bend; Soldier Bend, and Tobacco Island. All of these sites involve reconnection to the main channel either as secondary channels or backwaters.

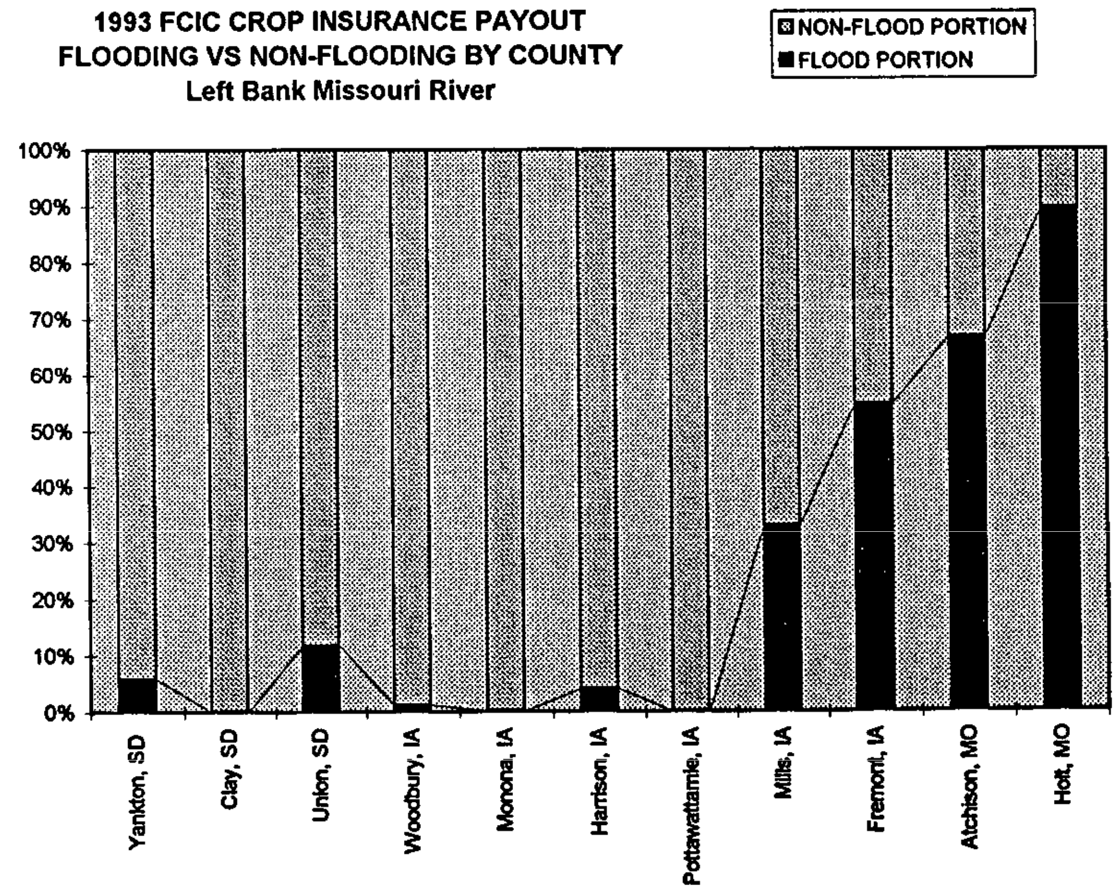
The Missouri River National Recreation Area, Nebraska is located in Thurston County, Nebraska, and includes the only unaltered reach of the Missouri River in the Omaha District below Gavins Point Dam. The area also has numerous access areas to the river for camping, canoeing, and fishing. High concentrations of bald eagles are attracted to the area because of the year-round open water below Gavins Point Dam which provides ample feeding opportunities. Pallid sturgeon, interior least terns, and piping plovers, all Federally listed threatened/endangered species, also take advantage of this unchannelized portion of the river.

Figure 5-3

COUNTY	FLOOD PORTION	NON-FLOOD PORTION
Yankton, SD	6%	94%
Clay, SD	0%	100%
Union, SD	12%	88%
Woodbury, IA	1%	99%
Monona, IA	0%	100%
Harrison, IA	4%	96%
Pottawattamie, I	0%	100%
Mills, IA	33%	67%
Fremont, IA	55%	45%
Atchison, MO	67%	33%
Holt, MO	90%	10%

COUNTY	MAJOR TRIBUTARY
Yankton, SD	James River
Union, SD	Big Sioux River
Woodbury, IA	Little Sioux River
Harrison, IA	4 Tribs, Overbank
Mills, IA	Interior Ponding
Fremont, IA	Interior Ponding
Atchison, MO	Nishnabotna River, Fed Levee Break
Holt, MO	Federal Levee Overtops & Ends

1993 FCIC CROP INSURANCE PAYOUT
FLOODING VS NON-FLOODING BY COUNTY
Left Bank Missouri River



Boyer Chute National Wildlife Refuge, DeSoto Bend National Wildlife Refuge, and Squaw Creek National Wildlife Refuge constitute the Federally managed areas. Boyer Chute, located in Washington County, Nebraska, is presently under development. The area includes a restored secondary channel and a diversity of wetland and riparian habitats. There will also be numerous recreational opportunities such as river access, fishing, and hiking.

DeSoto Bend National Wildlife Refuge (7,823 acres) is located in both Nebraska and Iowa. The refuge has many natural features, including a scenic overlook, Bullhead Pond, Cottonwood Trail, Wood Duck Pond, Prairie Land, and a 760-acre oxbow lake. DeSoto is visited each spring and fall by multitudes of migrating waterfowl and bald eagles as well as human spectators.

Squaw Creek National Wildlife Refuge (6,900 acres), located in Holt County, Missouri, was established in 1935 and provides habitat for a variety of riparian vegetation and wildlife. The area contains four large lakes which are surrounded by marshlands and provides fishing, hunting, observation towers, and foot trails. This site is also visited by migrating waterfowl and bald eagles each spring and fall.

Kansas City District Base Conditions

The Kansas City District covers the lower Missouri River Basin drainage area from Rulo, Nebraska, at RM 498.1 to St. Charles County, Missouri, on the left bank and St. Louis County, Missouri, boundary on the right bank. Portions of Missouri, Iowa, Kansas, Nebraska, and Colorado lie within the boundaries of the Kansas City District. The area has a diverse economy and includes agricultural, commercial, utility, industrial, transportation, recreation, and urban development.

Extensive and record flooding occurred throughout the lower Missouri River Basin during late spring and summer of 1993 in Missouri, central and east Kansas, southeast Nebraska, and south central and southwest Iowa. Levees failed or were overtopped. Residential, commercial, industrial and agricultural areas were inundated and severely damaged. Not only were crops lost but cropland was extensively damaged by sand deposits and scouring. Bridges, rail routes, local roads, State highways and even Federal interstate highways were damaged and closed for extended periods, causing major transportation disruption. Urban areas along the Missouri River within the Kansas City District that suffered major damages included St Joseph, Missouri, and Elwood, Kansas; Kansas City, Missouri and Kansas; and Riverside, Parkville, and Jefferson City, Missouri. Along the Kansas River, the Kansas communities of Kansas City, Muncie, Turner, Lawrence, and Manhattan experienced significant impacts. Other communities near tributaries experienced major damages, including Pattonsburg and Chillicothe, Missouri, near the Grand River; Excelsior Springs, Missouri, near Fishing River; and Natoma, Kansas, near the Saline River.

Kansas City District Evaluation Methodology

The 1993 Flood Economic Base Condition impacts were accumulated on a county level basis for Missouri, Kansas, Iowa, and Nebraska disaster counties located within the Kansas City District. Since the Kansas City District boundaries do not correspond to county boundaries, 1993 estimated flood impacts by county as reported in the 1993 Flood Data Collection database were allocated among the Districts so as to avoid double counting.

A second 1993 Flood Base Condition was also developed for purposes of the Floodplain Management Assessment. This second base condition was limited to impacts that occurred in "FPMA counties" in the Kansas City District. FPMA counties are those counties located adjacent to the Missouri River from about Rulo, Nebraska, downstream to the St. Charles and Franklin County boundaries and those located adjacent to the Kansas River from approximately Bonner Springs, Kansas, downstream to the confluence of the Kansas and Missouri Rivers. These counties are located in the reaches designated for the FPMA systemic analyses and impact study reach analyses.

Missouri FPMA counties considered in the Kansas City District analyses include: Andrew, Boone, Buchanan, Callaway, Carroll, Chariton, Clay, Cole, Cooper, Gasconade, Holt, Howard, Jackson, Lafayette, Moniteau, Montgomery, Osage, Platte, Ray, Saline, and Warren Counties. For Kansas, the FPMA counties within the Kansas City District include: Atchison, Brown, Doniphan, Johnson, Leavenworth, and Wyandotte Counties. One Nebraska FPMA county, Richardson, lies partially within the area covered in the Kansas City District analyses.

The following is a brief description of the types of damages and data estimates included in each impact category and a description of the data sources used for deriving the estimated socioeconomic 1993 flood base condition impacts for counties located within the Kansas City District.

The Kansas City District Base Condition impacts by category are primarily based on data developed for the Kansas City District 1993 Post-Flood Report and the 1993 Flood Data Collection Study (LMVD database). Primary data sources used include field surveys of communities along the Missouri River and its major tributaries and in-person and telephone interviews with City Clerks, business owners, utility company representatives, and others. In addition to survey data collected, secondary source data were obtained from State and other Federal agencies.

Flood Damage Reduction

Impacts in this category are Residential (Urban), Other Urban, Agricultural, and Other Rural.

Residential impacts represent damages to residential structures and contents in urban areas. Kansas City District impacts shown in this category are based on the LMVD database for Kansas City District counties.

Other Urban impacts are damages to commercial, industrial, transportation, pipeline, utility and public structures, equipment and inventory. Estimated cleanup costs and revenue losses are also included. Impacts shown are based on the LMVD database for Kansas City District counties.

Agricultural impacts are estimates of crop losses. Estimates of failed acres by county were provided by ASCS staff. An estimated $250 per acre damage which represents an actual loss per acre considering the time of the flood event was then applied to the estimated failed acres to compute damages in the Agricultural impact category.

ASCS disaster payments were analyzed to derive an estimate by county of crop damages due to overbank flooding versus excess precipitation. The estimated percentage of crop damages in the Kansas City District that were due to overbank flooding are shown by State below. For FPMA counties within the Kansas City District, a higher percentage of crop damages was due to overbank flooding (68 percent) than for all disaster counties in the Kansas City District as a whole (26 percent). Counties in Missouri experienced significantly greater crop damages due to flooding than counties in other States.

Flood Damage as a Percent of Total Crop Damage in Kansas City District Counties

	Disaster Counties	FPMA Counties
Missouri	65%	80%
Kansas	21%	39%
Iowa	4%	N/A
Nebraska	7%	52%
Kansas City	26%	68%

Other Rural impacts include estimated damages to farm buildings and equipment, farmland and farm ditch restoration costs.

Government Expenditure Change

Estimates of impacts in these categories are based on program data supplied by various Federal agencies and the Scientific Assessment and Strategy Team (SAST).

Emergency Costs are emergency, evacuation, and flood fighting costs as reported for the LMVD database.

Agricultural related disaster relief expenditures include FmHA Farm Loans, Natural Resources Conservation Service (NRCS) Emergency Watershed Program payments, ASCS Disaster Payments, Livestock Emergency Assistance Program payments, and Emergency Conservation Program flood related payments.

Human Resources Disaster Relief expenditures include Federal Emergency Management Agency (FEMA) buyout and hazard mitigation costs, mission costs, FmHA home loans, FEMA housing payments, FEMA individual and family grants, Small Business Administration (SBA) home loans, SBA rental and physical business loans, and SBA economic injury loans. (Although data for some of these may have been used as an indication of damages reported in the Flood Damage Reduction categories described above, figures shown in this category are the gross figures as reported for each county by the referenced agencies. Therefore, data reported in Flood Damage and Government Expenditure Change categories overlap and should not be added to obtain a "total" estimate of loss.)

Flood Insurance Payments include NFIP payments by county for losses from April 1, 1993 through September 30, 1993, and FCIC crop insurance indemnity paid for losses caused by flood.

Reduction of Risk

Critical Facilities in the first category include those facilities with potentially toxic releases which were damaged in the 1993 flood, such as hazardous materials production, storage and waste facilities. Critical facilities in the next category include essential utilities and services and emergency services known to have been damaged in the 1993 flood.

The Number of People Vulnerable shown in the base condition is a low end estimate based on the number of FEMA housing applicants by county. A high end estimate would be population of communities damaged during the 1993 flood. The 1990 population of communities in the Kansas City District affected by the 1993 flood was more than 3 million persons.

The Number of Communities Vulnerable is indicated by the number of communities receiving NFIP payments plus any others known to have suffered flood related damages during the 1993 flood.

Number of Residences Vulnerable is an estimate based on the residential structures identified in field surveys, when available; otherwise, the total of SBA home loans and FmHA home loans was used as an indicator when survey or other secondary data were not available.

Kansas City District Baseline Economic Impacts

Disaster Counties

Counties in the Kansas City District incurred estimated damages of more than $2.2 billion from the 1993 flood. The greatest impacts were in the Agricultural category, comprising more than 61 percent of the total impacts, followed by the Other Urban category representing 29 percent, Residential (Urban) with 5 percent, and Other Rural with 5 percent of total impacts.

Under Government Expenditures, disaster relief expenditures exceeded flood insurance payments for the Kansas City District disaster counties.

FPMA Counties

FPMA counties in the Kansas City District incurred damages of nearly $993 million from the 1993 flood. (Damages in counties designated as "FPMA Counties" account for more than 44 percent of total damages in the Kansas City District.) For FPMA counties, the greatest damage impacts were in the Other Urban category. Impacts in this category comprised nearly 55 percent of the total impacts, followed by the Agricultural category representing 30 percent, Other Rural with slightly more than 8 percent, and Residential (Urban) with 7 percent of total impacts.

Human Resource disaster relief expenditures significantly exceeded flood insurance payments for the Kansas City District FPMA counties as a whole.

Kansas City District Environmental Resources

Land Cover Distributions

The land cover distributions for the base condition were developed using digital data sets obtained from the SAST (LANDSAT imagery) and the U.S. Fish and Wildlife Service (National Wetland Inventory) as well as other sources. These data were initially trimmed to match the extent of the floodplain extent.

Non-Forested Wetlands

Non-forested wetlands include emergent and shrub/scrub wetlands. Forested wetlands are captured in the forest category. At the time of the 1993 flood, 6 percent of the total Kansas City District floodplain study area was classified as non-forested wetland. The portion of the Missouri River that was analyzed included ~66,000 acres of non-forested wetlands.

Threatened and Endangered Species

Threatened and endangered species include both Federal and State listings. This data was developed from the Natural Heritage Program databases and close coordination with the various Federal and State jurisdictional agencies. The data included reflects only those observations made within the floodplain. Both the number of species (i.e., diversity) and the total number of observations for all Federal and State threatened and endangered species occurring within the area are used to describe the base condition. In the Kansas City District study area, 30 threatened or endangered species were recorded, with 85 separate occurrences noted. Many of the threatened and endangered species were plants characteristic of wetland environments.

Forested Areas

Forested areas include both upland forests and forested wetlands. At the time of the 1993 flood, 5 percent of the total Kansas City District floodplain study area was classified as forest. The portion of the Missouri River that was analyzed included ~32,000 acres of forest.

Natural Floodplain Functions

The area inundated by the 1993 flood was used as the base condition under the Natural Floodplain Functions category. These cells were filled based on the hydrologic analysis and calculations of areas riverward of the current levee alignment.

Cultural Impacts

Little work has been done pertaining to cultural resources on the Missouri River floodplain. Historically, the Missouri River has meandered extensively across the floodplain, which limited the occurrence and opportunity for site development. The Corps of Engineers has documented the migration of this river since 1879.

Cultural resource sites discovered in conjunction with levee rehabilitation under Public Law 84-99 in response to the 1993 flood were early 20th century farmsteads that would probably be considered insignificant if the State had a management plan in place to address such sites. Prehistoric sites were located mainly on terraces proximate to the bluff line and on the bluffs above the floodplain. Such areas were avoided for obtaining borrow for repairing levees. None of the more prominent prehistoric sites were affected during the 1993 flood or the Public Law 84-99 repair effort. No historic standing structures were affected by the 1993 flood.

Open Space

Public land in the category of "Open Space" includes wildlife management areas, wildlife refuges, natural areas, National and State forests, and the like. The acreage presented in the summary tables includes the entire unit, even if only a portion of the unit falls within the study floodplain boundary. Recreation sites represent the number of Federal and State parks and local recreation areas located within the study area. Approximately 43,100 acres of public land and 20 recreation sites were present in the Kansas City District study area in 1993.

St. Paul District Base Conditions

The 1993 flood was a significant event along the Minnesota River from Mankato, Minnesota, to its confluence with the Mississippi River at Minneapolis and St. Paul, Minnesota. This was an "impact reach" examined in greater detail for this assessment. In this reach, the summer flood of record was experienced, and at Mankato, a historic record stage was recorded. Some $67 million in damages are estimated to have been prevented at Mankato as a result of the recently completed flood protection project. Along the main stem of the Mississippi River, from St. Paul to Lock and Dam 10, the flooding was only moderate at approximately a 20-year frequency, though severe enough so that navigation was disrupted by closure of the locks from 1 day at Lock and Dam 4 to 2 weeks at Lock and Dam 10. Flooding was more severe locally along several tributaries emptying into the Mississippi River from Wisconsin, including the Black River (especially at Black River Falls, Wisconsin), the Baraboo River in the Wisconsin River basin, and the Chippewa River at Eau Claire, Wisconsin.

Within the upper Mississippi River watershed in the St. Paul District, 35 counties in Minnesota, 25 in Wisconsin, and 2 in Iowa were included in Federal disaster declarations. These 62 counties comprise the Column A Base Condition for the summary impacts table for St. Paul District. Of these counties, 22 were examined for impacts in greater detail by virtue of their location adjacent to the Minnesota River impact reach or to the Mississippi River main stem. These comprise the Column B Base Condition shown in the summary impacts table. These counties are listed as follows:

- Minnesota: Blue Earth, Carver, Dakota, Goodhue, Houston, Le Sueur, Nicollet, Ramsey, Scott, Sibley, Wabasha, Washington, and Winona.

- Wisconsin: Buffalo, Crawford, La Crosse, Pepin, Pierce, Trempealeau, and Vernon.

- Iowa: Allamakee, Clayton.

A summary of the flood related impacts and losses from the 1993 event for the upper Mississippi River Basin in the St. Paul District is found in the data recorded in Columns A and B of the District Summary Impacts Matrix table at the end of Chapter 9.

St. Paul District Baseline Economic Impacts

The 1993 flood damages experienced in the St. Paul District portion of the upper Mississippi River Basin were largely agriculture related. It is conservatively estimated that at least $488 million in losses to agriculture were incurred for the 62 counties included in this assessment. Substantial additional agricultural damages were experienced in Federally declared disaster counties in northwestern Minnesota and eastern North Dakota that belong entirely or primarily to the Red River of the North drainage basin and are not included in this assessment. The basis for this estimate is a county by county review of Federal Crop Insurance payments and disaster relief assistance payments, the latter made by the ASCS, now a part of the Consolidated Farm Services Agency. Crop insurance and disaster aid may typically cover only 60 to 70 percent of total crop losses, so it is quite certain that the reduced value of total crop production was considerably in excess of half a billion dollars for this 62-county area.

Crop insurance payouts for this area are estimated to be $216 million, and disaster aid expenditures for agriculture relief are estimated at $284 million. It is interesting to note that estimates of crop damage, crop insurance payments, and disaster relief expenditures are proportionately far less for the 22 counties located adjacent to the main stems of the Minnesota and Mississippi Rivers in the St. Paul District than for the remaining counties. This no doubt is partly a reflection that some of the counties adjacent to the rivers are less agriculturally oriented, but it also indicates that most of the crop losses in the St. Paul District were not caused by overbank flooding in the main stem rivers.

Confirmation of this finding results from inspection of FCIC payments for this 62-county area. There are more than a dozen causes of loss for which crop insurance payments may be made. Only $2.3 million, or just in excess of 1 percent of total FCIC indemnity payments for this area in 1993, were attributable to "flooding." The category "excess rainfall" accounted for $128 million in FCIC payments, or almost 60 percent of total payments for this area. Clearly, for this upper portion of the upper Mississippi River watershed in the St. Paul District, it was the unusually heavy, persistent, and widespread rainfall in more upland areas that made many farm fields unworkable, not overbank flooding from the main stem Minnesota and Mississippi Rivers. This is not surprising, because farming is not an intensive floodplain land use along the lower Minnesota River below Mankato or along the upper Mississippi River below St. Paul within the St. Paul District.

Residential and other urban damages were widely but relatively lightly distributed with a concentration of losses in Lyon County (Marshall), Minnesota, and Jackson County (Black River Falls), Wisconsin. While several local areas were hit hard, the relatively limited magnitude and duration of flooding in the St. Paul District did not compare with the more widespread damages to residential and other types of structures and facilities experienced in the other four District areas. The estimates of emergency response costs and National Flood Insurance indemnity payments in St. Paul District counties, in comparison with estimates from the other four Districts, also reflect a generally lower level and extent of damaging flooding. The large amount of human resources disaster relief expenditures is attributable primarily to flood related unemployment assistance.

St. Paul District Reduction of Risk Impacts Categories

Relatively few critical facilities were affected by the 1993 flood in the St. Paul District area. Two Environmental Protection Agency (EPA) designated Superfund sites, previously used as landfills, are located in the Minnesota River floodplain. One is a 126-acre site in Burnsville, Minnesota, and the other is a 3-acre site near the Minneapolis-St. Paul International Airport. There are no problems known to have been caused by these sites. A small oil spill from fuel barrels was reported at Durand, Wisconsin, in Pepin County.

Other facilities affected within the 22-county area in the St. Paul District include eight highway bridges over the Minnesota River that were closed between Mankato and the Twin Cities; a railroad line that was flooded along the Minnesota River; closure of Holman Field, the downtown St. Paul airport; a water treatment plant shutdown in Le Sueur, Minnesota; a sewage treatment plant shutdown in St. Peter, Minnesota; and a wastewater treatment plant flooded in Osseo, Wisconsin.

In the entire St. Paul District area, there were more than 11,000 applications for either individual/family assistance from FEMA or disaster assistance loans from the SBA. At least 64 communities within the basin are known to have experienced some degree of flooding based on a review of the flood event contained in the St. Paul District post-flood report. More than 2,000 residential structures are estimated to have been damaged by flooding.

St. Paul District Baseline Environmental Resources

Environmental base conditions for the St. Paul District study area (Mankato, Minnesota, to Guttenberg, Iowa) at the time of the 1993 flood are taken from the Environmental Resource Inventory (Appendix C). This data was compiled by a contractor using a wide array of available data, including digital GIS data, Federal and State agency staff, reports, etc. The base data covers the entire floodplain of the study reaches under investigation.

Land Use

The land use distributions for the base condition were developed using digital data sets obtained from the SAST (LANDSAT imagery) and the U.S. Fish and Wildlife Service (National Wetland Inventory) as well as other sources. The St. Paul District study area consists of approximately equal proportions of non-forested wetlands and floodplain forest (forest and forested wetland). These two categories account for almost 30 percent of the land use in the floodplain (~150,000 acres). An extensive amount of open water (~165,000 acres) also exists in the St. Paul District study area, including over 1,000 individual lakes and ponds. This is due in part to an essentially non-leveed floodplain in this portion of the system. Also, a series of dams on the Mississippi River is used to support navigation. These structures cause extensive pooling of water, especially in lower reaches of the navigation pools.

Threatened and Endangered Species

The St. Paul District shows the highest number and number of occurrences of threatened and endangered species in the overall FPMA study area. These high numbers are likely related to the large amount of public land (~77,000 acres, 14 percent) in the floodplain, and the large number of fish and wildlife management areas, including three National Wildlife Refuges: the Minnesota Valley National Wildlife Refuge, the Trempealeau National Wildlife Refuge, and the Upper Mississippi River Wildlife and Fish Refuge. These areas provide important migration corridors and other critical habitat requirements, as well as some degree of protection from human-induced disturbance that would occur in non-protected areas.

Cultural Impacts

Responding to flood damage to historic and archeological sites, Congress provided $5 million to the National Park Service (NPS) in August 1993. With this funding, the NPS provided technical assistance and emergency stabilization for flood-damaged archeological sites and historic structures listed on the National Register of Historic Places. The National Trust for Historic Preservation received $2 million from the NPS and $3 million went to the nine States affected by the 1993 flood (Wisconsin Preservation, July-August, 1994). This funding allowed Iowa, Minnesota, and Wisconsin to produce written summaries of the cultural resources affected by the flood in their States. These reports provided the principal source of information on the nature and extent of damage to cultural resources in the District. The nature and extent of cultural resources in the Mississippi River valley in the St. Paul District are detailed in the Environmental appendix to this report (Appendix C).

The 1993 flood had its greatest impact to cultural resources on the Minnesota River and the Mississippi River just downstream from the Minnesota River's mouth. With funding provided from the NPS, the Minnesota State Historic Preservation Office conducted general surveys and detailed site assessments to determine the level of flood damage. Reflecting the size of the flood on the Minnesota River, archeological resources along its course suffered greater damage than sites along the Mississippi River.

Rock Island District Base Conditions

Base Condition Impacts include physical flood damages as well as emergency response and disaster relief costs. For the Rock Island District, as with the other Districts, the Economic Base Condition Impacts are comprised of two sets of data. One data set is for all counties within the District which were Federally declared disaster counties during the summer of 1993. The second Base Condition data set includes information for counties adjacent to the FPMA river reaches. Analysis of changes in flood impacts projected from Action Alternatives and Policy Scenarios will be founded on the FPMA river reach Base Condition Impacts.

Three FPMA river reaches are within the District: (1) the Mississippi River from Guttenberg, Iowa, to Saverton, Missouri; (2) the Des Moines River from Saylorville Lake, Iowa, to its confluence with the Mississippi River; and (3) the North Fork Raccoon River in Dallas, Greene, and Polk Counties, Iowa. FPMA river reach counties by State in the Rock Island District are listed below.

FPMA COUNTIES IN ROCK ISLAND DISTRICT

Iowa	Iowa	Illinois	Missouri	Wisconsin
Clayton	Polk	Jo Daviess	Clark	Grant
Dubuque	Warren	Carroll	Lewis	
Jackson	Marion	Whiteside	Marion	
Clinton	Mahaska	Rock Island		
Scott	Wapello	Mercer		
Muscatine	Davis	Henderson		
Louisa	Van Buren	Hancock		
Des Moines	Dallas	Adams		
Lee	Greene			

County-wide information from several sources was used to gather flood damage estimates for various impact categories. These sources are detailed in the Evaluation appendix (Appendix B).

Rock Island District Baseline Economic Impacts

There were significant damages both to agriculture and to residential and other structures from flooding and excess rainfall during the summer of 1993 in the Rock Island District counties that were Federally declared disaster areas. In the 30 counties comprising the FPMA "impact reach" counties in Rock Island District, estimates are more than $128 million in residential damages, $223 million in other urban damages, and $141 million in crop losses. For all declared disaster counties in the District, crop losses were estimated to be in excess of $1.2 billion.

Disaster relief payments exceeded insurance payouts for both agriculture and human resource related needs. In the 30 impact reach counties, some $72 million in agricultural disaster relief was paid, while FCIC payments were $65 million. For human resource needs, more than $135 million in disaster aid was paid, while NFIP payments were $83 million. When examining ALL the declared disaster counties in Rock Island District, almost $700 million was paid in disaster relief for combined agriculture and human resource needs.

Reduction of Risk Impact Categories

For practical purposes, the number of people directly or indirectly affected by the 1993 flood is indeterminable. Obviously, those people were very directly affected who resided in floodplain neighborhoods that were inundated. Those owning businesses or working in floodplain locations also were very directly affected. However, there were numerous situations in which thousands of people were affected by the flood, even though they were not occupants of the floodplain. Transportation routes were cut off, essential public services were lost or hampered to varying degrees, water supplies and other utilities were impaired, and production and employment capacities were severely affected.

For the FPMA base condition impacts, some 11,000 residential structures are estimated to have been damaged in the Rock Island District impact reach counties. The number of communities vulnerable during the 1993 flood reflects estimates of those instances of direct floodwater inundation. At least 78 communities were affected. This delineation, as with the number of people affected, does not account for a much broader group of community/social impacts. Many communities had levee systems which performed well or where floodfighting reduced potential damages. Those communities and residences were still vulnerable, and great effort was extended for emergency preparedness and floodfighting, not to mention anxiety due to the flood threat. Social service resources were often strained to the limit. Government resources at all levels were severely tested. Comprehensive analysis of flood impacts on community and social well-being is not addressed in this assessment.

Rock Island Baseline Environmental Resources

Unique Habitats

Many unique habitats found in the Rock Island District's study reaches have been protected by county, State, and Federal agencies (see the Environmental Resources Inventory, Appendix C). These areas have been set aside to protect habitats that are important to unique plant and animal species, migratory stopping places for waterfowl, and wildlife sanctuaries. Many of these areas are used for education areas, hunting and fishing sites, sightseeing, and other human uses.

Several programs and policies have been enacted to either preserve protected areas or enhance existing wild lands for their perpetuation of benefits not only to the wildlife that use them, but for human use. Currently, the Corps of Engineers administers forestry management on the bottomland timbered portions of the Mississippi River. Timber stand improvements, even age management, and species diversity are some of the goals in this forestry program. The Environmental Management Program and other Federal programs are currently restoring and enhancing wetlands that have been affected primarily by siltation. Several sanctuaries administered by county and State governments protect mussel communities, rare turtle nesting areas, and winter eagle roost areas.

Threatened and Endangered Species

Throughout the Rock Island District, many species are either State or Federally listed as threatened, endangered, and rare. These include 23 plants, 17 fish, 3 mammals, 7 birds, 10 reptiles and amphibians, and 14 other species such as mussels, snails, and insects.

Public Use Areas

To accommodate people's attraction to the rivers and water based recreation, many sites have been established by private organizations, city, county, State and Federal agencies. Again, most of these sites are detailed in Appendix C.

Flood Impacts

General impacts to threatened and endangered species are not known at this time. While these species are resilient to floods, even those as significant as the 1993 flood, these species now inhabit, for the most part, essentially an unnatural floodplain that has been leveed, pooled, and affected by pollution and development. Short-term impacts from the flood (generally 5 years after the event) are being assessed, as well as long-term monitoring on these species and the habitats in which they are found.

Activities at public use sites range from sightseeing to waterskiing. During the 1993 flood, practically all recreation was halted on the rivers studied in this report. Post-flood repairs to major facilities are still underway. These repairs include restoring bathrooms, removing silt from boat ramps, repairing roads, replacing electrical lines, and many more efforts to bring these recreation facilities and sites back to pre-flood conditions.

Natural resources during and after the flood showed a wide variety of responses to flooding -- some were devastating while others were beneficial. Initial studies of fish generally indicated that many species used the floodplain for spawning and rearing habitat. Maher, *et al.* (1994) found up to 37 species using floodplain habitats that were previously leveed off from the river. The floodplain offered a habitat of slower-moving water, abundant escape cover, and a highly productive food base for first year fish.

The production of microcrustaceans and aquatic insects in the inundated floodplain occurred at just the time larval fishes needed food (Bhowmik, *et al.*, 1994).

The 1993 flood impacts to vegetation were mixed. In many choked backwater areas, vegetation was completely removed or set back. While setting back vegetation in some of these areas opened them up and made them more accessible to wildlife use, other areas that were completely voided of vegetation were historic waterfowl migration feeding sites. Ducks and geese had to seek alternative, usually less productive, areas to fuel their migrations.

It is still too early to determine what the long-term effects of the flood will be on many forms of vegetation and wildlife. Hanging in the balance are animals like native mussels, which were in a decline before the flood. Although species using rivers and floodplains have adapted to seasonal floods, impacts to delicate species may be exacerbated by a major flood, even though direct and indirect impacts by humans are generally recognized as having a greater influence.

<u>Cultural Resources</u>

Cultural resource base conditions derived from the 1993 flood impacts for the three reaches discussed below are judged to be -2 for both historic structures and archeological sites. This is based on an arbitrary scale of 0 to -5.

Mississippi River Floodplain: Muscatine, Iowa, to Saverton, Missouri (River Reach Code MI4) - This reach covers 156 miles of floodplain between RM 457 and RM 301. Here, the floodplain cuts across portions of 14 counties -- 6 in Illinois and 4 each in Iowa and Missouri. The 500-year floodplain covers approximately 458,900 acres between Muscatine and Saverton. The number of recorded cultural resource sites in this reach is 551.

Historic structures and/or districts (n = 32) listed on the National Register of Historic Places within the 500-year floodplain totaled 32 (see Appendix C for a complete listing). This information was acquired from the National Park Service and is current as of February 4, 1994.

Knowledge of the extent of buried archeological sites remains extremely limited. Virtually no sampling has been conducted to determine the extent of buried sites within the river's vast alluvial deposits. These deposits are known to contain buried sites of great age and at depths reaching to several meters below the present surface. Even many protohistoric and early historic sites are buried, lying under thick blankets of 19th and 20th century alluvium.

Des Moines River Floodplain: Boone, Iowa, to Red Rock Dam (River Reach Code MIT11) - Much of this reach, except for areas within and immediately adjacent to Des Moines, Iowa, includes Corps of Engineers fee title and easement lands associated with Saylorville Lake and Lake Red Rock.

Benn (1986:3) identified 521 cultural resource sites on the Corps Saylorville Lake fee title and easement lands. Presently, 32 of these sites are considered eligible for listing on the National Register of Historic Places, while 164 still require evaluation to establish National Register status (U.S. Army Corps of Engineers 1990, as revised). All others have been determined not eligible for the National Register.

Information current as of October 1994 for Lake Red Rock listed 466 cultural resource sites on the Corps fee title and easement lands. No sites were identified as eligible for inclusion on the National Register of Historic Places; 218 sites were listed as not eligible; 194 were listed as still in need of testing to establish National Register status; and 54 were listed with no indication of National Register status.

None of the sites at Saylorville Lake or Lake Red Rock include standing structures eligible for the National Register. However, National Register structures and/or districts have been tabulated for areas within the 500-year floodplain of the Des Moines River in Polk County: five structures and/or districts occur within 42,700 acres in the 500-year floodplain. The floodplain is not defined in the areas above and below Polk County.

Raccoon River Floodplain: Dallas and Polk Counties, Iowa (River Reach Code MIT14) - Only one National Register listing was found within the 500-year floodplain for this reach. The listing is limited to the 6,900 acres of floodplain in Polk County because the floodplain is not defined in Dallas County.

St. Louis District Base Conditions

St. Louis District Baseline Economic Impacts

Within the St. Louis District boundaries, 26 counties were Federally declared disaster areas during the 1993 summer flood. St. Louis District is the only instance where all declared disaster counties were also considered "impact reach" counties for the purpose of FPMA analysis. The 26 counties are listed below:

Illinois	Missouri
Alexander	Cape Girardeau
Brown	Franklin
Calhoun	Jefferson
Cass	Lincoln
Greene	Perry
Jackson	Pike
Jersey	Ralls
Madison	St. Charles
Monroe	St. Louis (County and City)
Morgan	St. Genevieve
Pike	Scott
Randolph	
St. Clair	
Scott	
Union	

Residential and other urban damages were proportionately by far the greatest in the Federally declared disaster counties of St. Louis District. More than $431 million in residential damages and $549 million in other urban damages were experienced. By comparison, agricultural crop losses were estimated to be $169 million. Emergency response costs exceeded $101 million.

St. Louis District data is also distinctive in that insurance claims payments slightly exceeded the amount of Federal disaster aid provided for residents in these disaster counties. National Flood Insurance claims ($133.7 million) essentially equaled disaster aid for human resources ($134.3 million). In the agricultural sector, Federal Crop Insurance claims ($44.9 million) exceeded agricultural disaster relief ($36.4 million) that was provided.

Reduction of Risk Impact Categories

Approximately 250 critical facilities within the St. Louis District were affected by the 1993 flood. Other critical facilities are located in the floodplain and could be vulnerable in future flood events.

At least 23,460 residential structures were damaged by the flooding in at least 50 communities. Some 62,180 people are estimated to have been directly affected by flood losses. These estimates do not include the hundreds of thousands of other people whose lives were affected by transportation disruptions that made commuting to work difficult or the loss of business that resulted due to the havoc caused by flooding.

St. Louis District Baseline Environmental Resources

Natural Resources

Of the half-dozen land use/land cover types occurring within the entire St. Louis District study area, agriculture predominates (64 percent), followed by forest (15 percent), non-forested wetland (9 percent), water (8 percent), and urban (5 percent). Barren areas, such as beaches, represent less than 1 percent of the 1,731,660-acre floodplain area. Of the total wetland land cover type, 53 percent is forested and 47 percent is non-forested. Most of the area identified as water and barren represents the 380 miles of the Mississippi and Illinois Rivers at normal stage.

The St. Louis District study area on the main stem Mississippi River (excluding FPMA tributaries) contains the largest total floodplain acreage of the FPMA Districts. This reflects the generally increasing width of the Mississippi River floodplain from north to south.

Much of the public land in the St. Louis main stem area is located along the 100-mile-long pooled portion of the Mississippi River north of St. Louis. Little public land lies along the 200 miles of open river from St. Louis to Cairo, Illinois.

Levees protect 66 percent of the floodplain within the entire St. Louis District study area. Seventy-five percent of the urban land use in the study area is protected by levees and 85 percent of the agricultural land use is protected by levees. Thirty-four percent of the floodplain is unprotected.

Cultural Resources

Sources used to assess the flood damage to the cultural resources of the St. Louis District include several recent descriptive reports, several older study documents related to past floods and floodplain use, recent survey data, and personal communications. First, "The Great Flood of 1993 Post-Flood Report" was a valuable resource. Portions of "A Blueprint for Change" (the Galloway Report) were also used. Second, reports, documents, and data on file in the St. Louis District Planning Division were critically important. Third, recent survey data of selected floodplain areas known to have historic properties were valuable in preparing the St. Louis District cultural narrative. Finally, many contacts were made by E-mail and telephone to the historic preservation agencies of Missouri and Illinois and to other State agencies. The result was a compilation of data giving a general picture, with additional specific facts for some localized areas.

Roughly 80 percent of the Mississippi River floodplain within the St. Louis District was inundated at some time during the flood of 1993. In the absence of thorough, post-flood surveys covering large areas of the rural bottomlands, it was decided to use the same figure as an estimate of the level of flood-caused damage to historic and prehistoric sites. It was assumed, therefore, that approximately 80 percent of the cultural resources in the District were, in some way, affected by the flood. This estimate is no doubt flawed. It is clear, for instance, that historic properties are not evenly distributed across the landscape. It is equally clear that many fewer historic sites were damaged than prehistoric sites. This is true for three basic reasons: many historic sites were protected by flood control projects; there are many more prehistoric sites than there are historic sites; and the more numerous prehistoric sites often lie outside of levees, or behind low agricultural levees that were overtopped. However, while these are valid criticisms, it is still felt that about 60 percent of the historic sites and at least 80 percent of the prehistoric sites in the District sustained some damage in the flood of 1993.

CHAPTER 6 - "SCENARIO" DESCRIPTIONS (POLICY AND PROGRAM CHANGES AFFECTING USE OF FLOODPLAINS)

Scenario Development

A challenge for this assessment is to examine the wide range of approaches that can be taken both to reduce damages to human resources and to maintain the value of natural floodplain resources. In order to ensure that nonstructural approaches were considered as a major part of this effort, the concept of "scenarios" was developed. Scenarios provide a context for the evaluation of potential changes in floodplain land use and flood impacts linked to changes in nonstructural policies and programs for this assessment.

The basis for evaluation is to attempt to quantify the CHANGES in impacts and resource values that might have resulted in 1993, IF a number of nonstructural policy and program measures had been in place. The 1993 flood damages and other losses, as discussed in Chapter 5, serve as the baseline for making the comparisons of possible changes in impacts and resource values.

Three scenarios of nonstructural policy and program measures are developed in this assessment. Each scenario contains at least one measure from each of seven policy and program categories. A detailed listing of the various program and policy measures that comprise the three scenarios is provided in this chapter.

The seven policy and program categories listed below, among others, have received much attention over the years as being particularly important in creating incentives for how floodplain resources will be used. These categories are identified in columns C through I in the first of two evaluation tables described in Chapter 4. They are each included in development of the three scenarios:

CATEGORY C. National Flood Insurance Program regulations.

CATEGORY D. State floodplain management and zoning practices.

CATEGORY E. Local floodplain management and zoning practices.

CATEGORY F. Community relocation, flood hazard mitigation, and land use conversion programs.

CATEGORY G. Flood disaster relief programs.

CATEGORY H. Floodplain wetland restoration policies.

CATEGORY I. Agricultural support policies related to floodplain use.

Floodplain related policy and program issues used to develop the scenario descriptions were located from sources such as the Interagency Floodplain Management Review Committee (1994), the Association of State Floodplain Managers (ASFPM) (1994), and the Upper Mississippi River Basin Association (UMRBA) (1994). The Floodplain Management Assessment (FPMA) evaluation framework developed a RANGE of policy and program measures to differentiate three scenarios. The contents of the scenarios were devised for the purpose of completing evaluations of potential impacts as part of the FPMA. They are not attributable to any other source.

The scenarios serve as a means for identifying the potential significance of changes in floodplain land use and flood impacts that could have resulted in 1993 if the policies and programs had been in place. While it is important to be able to clearly differentiate a wide range of conditions as represented by the three scenarios, a countless number of scenarios could be developed. The objective of the evaluation process is not to perfect the scenarios; it is rather to be able to show which of the policy and program changes appear to be most robust in responding to environmental, economic, and social needs related to floodplain management.

Several comments received on the draft FPMA report made suggestions for either increasing the number of scenarios or changing features within the three scenarios that were evaluated. There is certainly room for additional analyses to be conducted that would better identify and quantify the impacts that could potentially be associated with implementation of a number of the measures that were examined. There are also other policy or program measures of interest that could be devised to respond to particular floodplain management problems or issues. Scenarios in this assessment served as a context and a framework for analysis, but it is the individual measures within the scenarios that served as the focus for the assessment of possible impacts.

A summary analysis of the measures comprising the scenarios is presented in Chapter 7 along with completed impacts matrix tables for each of the three scenarios at the end of the chapter. A substantial amount of supporting information on the scenario measures and policy/program categories, including matrix table cell notes and descriptions, is located in Chapter 3 of Appendix B.

Scenario Descriptions

SCENARIO 1: EXISTING FLOODPLAIN POLICIES AND PROGRAMS MAINTAINED WITH KNOWN CHANGES INCLUDED

This scenario outlines a continuation of the floodplain management policies and programs presently in place while also recognizing, when known, changes in these policies and programs that are occurring. These include Federal Emergency Management Agency (FEMA) buyouts of more than 5,000 substantially damaged structures in the floodplain and 1994 legislation reforming aspects of the national flood insurance program. Likewise, State and local governments in many cases are actively responding to impacts caused by the 1993 flood. The philosophy underlying this scenario, however, is that changes in floodplain management will come, in most cases, somewhat slowly and incrementally over time.

SCENARIO 2: FLOODPLAIN POLICY AND PROGRAM PROPOSALS OF THE REVIEW COMMITTEE, UMRBA, AND ASFPM ARE IMPLEMENTED

This scenario assumes that many of the floodplain policy and program proposals presented in the Interagency Floodplain Management Review Committee report ("Galloway Report"), along with position papers prepared by the Upper Mississippi River Basin Association and the Association of State Floodplain Managers, are implemented. The measures in this and the other scenarios focus on policies and programs that have the potential for changing floodplain management and use "on the ground." Because of uncertainty over specific provisions of the 1995 Farm Bill, possible actions in this area are included under this scenario. Other issues, related to institutional and administrative reforms, were to be considered outside this evaluation framework.

The philosophy underlying this scenario assumes a more active response to the 1993 flood and a persistent pursuit of floodplain policy and program reforms. Major objectives to be achieved include reduction of risk to lives and property, economically efficient use of floodplain resources, and environmental enhancement of floodplain resources.

SCENARIO 3: AVOIDANCE OF FLOOD RISK TO LIVES AND PROPERTY AND RESTORATION OF NATURAL RESOURCES OF THE FLOODPLAIN ARE MORE AGGRESSIVELY PURSUED

This scenario is based on a very active pursuit of floodplain management reforms, emphasizing restoration of environmental resources in the floodplain and maximum avoidance of risk from flood damages and to loss of lives as the two primary policy objectives. Long-term planning in the use of floodplains at all government levels discourages development of floodplain areas even where it may be economically viable to do so. The philosophy underlying this scenario is that reliance on natural features in the floodplains is encouraged. New structural works to manage floods will be used only to protect existing development and will not be constructed to protect areas of potential future development. Avoiding exposure to flooding is the foundation in developing floodplain management policies and programs under this scenario.

Policy and Program Categories Varying with Scenarios

The policy and program categories vary between scenarios assuming implementation of various MEASURES. These measures are summarized below. (NOTE: Measures were assigned to FPMA team members for analysis in September 1994. Some additional explanation of what several of the measures entail is provided in response to comments received on the draft report in April/May 1995. The measures are NOT recommendations. They have been examined for the purpose of analysis to gain a better understanding of what positive and negative impacts could result if a measure were to be implemented.)

Category C - National Flood Insurance Program (NFIP) Regulations

Scenario 1 Measures

* A 30-day waiting period for policies to take effect, as opposed to a 5-day base condition (included in 1994 legislation)
* Enforced compliance of flood insurance requirements for structures with mortgages in the 100-year floodplain (included in 1994 legislation)
* Pre-flood market values instead of replacement costs to be used in determination of substantially damaged structures (confirmed in 1994 legislation)
* No changes in premium structure assumed (to be studied under the 1994 legislation)
* No expansion of riverine areas covered by flood insurance requirements assumed

Scenario 2 Measures

* Establish a sliding scale of escalating premiums to place a greater burden on repetitively damaged structures
* Flood insurance claims filed for structures outside a mapped floodplain causes the area to be mapped as floodplain and triggers community requirements to manage the area as such
* Actuarially based flood insurance requirements are applied to structures behind all levees with less than standard project flood protection
* Flood insurance maps will not be revised to remove properties based on fill (A homeowner could raise his or her home, but the site would not be removed from flood maps, so that any owners or subsequent buyers of undeveloped adjacent properties would not be misinformed about the continued risk of flooding.)
* All communities with flood hazard areas that are developed or could be developed will be mapped, and increased funding to accomplish this will be provided

Scenario 3 Measures

* Provide authority for individuals to sue agents and lenders who fail to provide notice of flood insurance purchase requirements

* NFIP Community Rating provisions are MANDATED to ensure adherence to practices achieving flood damage avoidance

* Additional funding for completion and update of flood insurance rate maps (FIRMs) is provided (beyond NFIP premiums); maps are based on FUTURE conditions hydrology

Category D - State Floodplain Management and Zoning Practices

Scenario 1 Measures

* Variety of State policies and programs (see "Galloway Report," Attachment 1) assumed to continue without major change

* NFIP funding provided (up to $1.5 million annually) for State (and local) floodplain management and advanced mitigation planning (included in 1994 legislation)

Scenario 2 Measures

* Locational requirements and contingency planning requirements for critical facilities are tightened to avoid the standard project flood or provide protection against the standard project flood

* Community Development Block Grants through the Department of Housing and Urban Development (HUD) are provided which finance relocations in NON-DISASTER situations, once cost sharing requirements are met by State/local governments

Scenario 3 Measure

* State governments as well as Federal agencies are required to meet the standards contained in Executive Order 11988

Category E - Local Floodplain Management and Zoning Practices

Scenario 1 Measure

* No major changes in local floodplain management and zoning trends; standards for participation in NFIP generally adhered to

Scenario 2 Measure

* Community Rating System (CRS) features are promoted; premiums are reduced for structures in participating communities from the current 5 percent discount to as much as 20 to 25 percent (The Federal Insurance Administration has established a CRS to encourage communities participating in the NFIP to undertake floodplain management activities that go beyond the activities required for program participation. FEMA has commented that the existing program already provides for discounts of up to 40 percent depending on the class rating of the community.)

Scenario 3 Measure

* Communities are required to obtain private insurance to cover flood losses to public facilities in order to receive supplemental post-flood disaster assistance

Category F - Community Relocation, Flood Hazard Mitigation, and Land Use Conversion Programs

Scenario 1 Measures

* FEMA buyouts of 5,000 or more substantially damaged structures are completed (FEMA has commented that 177 approved projects consisting of 8,251 parcels are being pursued)

* Up to $20 million funding to be provided annually for "National Flood Mitigation Fund" from NFIP premiums, with cost sharing requirements (included in 1994 legislation)

* 1993 Hazard Mitigation and Relocation Assistance Act (Public Law 103-181) and FEMA interim rule in place increasing Federal share for eligible hazard mitigation and relocation from 50 percent to 75 percent

Scenario 2 Measures

* Federal leases in floodplains are phased out

* Flood hazard mitigation funds for floodproofing, elevating, or relocating structures are made available as quickly as construction funds for repairs are in place

Scenario 3 Measure

* Cost shared funding for acquisition of all structures repeatedly flooded is provided by Federal/State/local governments

Category G - Flood Disaster Relief Programs

Scenario 1 Measure

* Existing programs, except where noted elsewhere, are assumed to continue independently (see "Galloway Report," Attachment 1, for brief program descriptions)

Scenario 2 Measures

* All disaster assistance to be strictly cost shared at 75/25 percent and made consistent across all Federal relief programs, and equal to mitigation cost sharing requirements (NOTE: The "base condition" has seen Congressional mandating at 90/10 percent cost sharing in recent disasters.)
* Greatly reduce public assistance grants to communities not participating in the NFIP

Scenario 3 Measures

* Post-flood disaster relief is eliminated for those communities and individuals within designated STANDARD PROJECT FLOOD areas not participating in the NFIP
* Repeat flood DISASTER payments to individuals and communities are eliminated (All should be in the flood insurance program, which would cover multiple events assuming compliance with NFIP provisions. FEMA has commented that a provision in the NFIP 1994 reform legislation largely accomplishes this measure.)

Category H - Floodplain Wetland Restoration Policies

Scenario 1 Measure

* Existing wetland protection and restoration policies are assumed to continue without major change (see "Galloway Report," Attachment 1, for brief program descriptions)

Scenario 2 Measures

* Increased funding for Refuge Revenue Sharing Act provided to cushion local governments' tax base from land conversion effects
* Stream and riparian restoration program established with Federal funding and technical assistance from the U.S. Department of the Interior, the U.S. Department of Agriculture, and/or the Environmental Protection Agency
* Floodplain wetlands targeted for priority enrollment in the Wetlands Reserve Program
* Nominal funding for land acquisition for habitat improvement under the Upper Mississippi River System-Environmental Management Program (UMRS-EMP)

Scenario 3 Measure

* New funding is provided to initiate a lower Missouri River Environmental Management Program with land acquisition for habitat improvement allowed

Category I - Agriculture Support Policies Related to Floodplain Use

Scenario 1 Measures

* Federal crop insurance program reform requiring participation of all farmers receiving other farm program benefits is assumed to be in place (included in 1994 legislation)
* Other incentives, such as Wetland Reserve Program, Emergency Wetland Reserve Program, and Conservation Reserve Program, are

assumed to continue but not extend beyond the dates of existing authorization language (see "Galloway Report," Attachment 1, for brief program descriptions)

Scenario 2 Measures

* Levee repair criteria are consistently and rigorously applied, with increased consideration of repetitive losses, maintenance costs, and environmental and social impacts of levee restoration versus other alternatives

* 1995 Farm Bill will continue conservation and voluntary acquisition programs emphasizing restoration of marginal agricultural areas frequently flooded to wetlands and natural habitat

* Post-flood land restoration activities, including explicit consideration of environmental attributes, are formalized to expand opportunities for pursuing buyout options (Louisa levee district No. 8 in Iowa as the prototype)

Scenario 3 Measures

* Crop insurance premium rates reflect actuarial risk for farming behind levees in floodplain area

* Expanded implementation of existing upland farm land use management practices, such as terracing, no-till farming, construction of windbreaks, and sediment traps to reduce peak flood runoff and retain soil on the landscape

CHAPTER 7 EVALUATION OF SCENARIO MEASURES

Introduction

This chapter presents the evaluation of a wide range of measures in seven different policy and program categories that have been examined in this assessment. The seven categories, in the order they are discussed in this chapter, and in order from Columns C through I in the impacts matrix tables for each of the three scenarios, are:

C National Flood Insurance Program Regulations
D State Floodplain Management and Zoning Practices
E Local Floodplain Management and Zoning Practices
F Community Relocation, Flood Hazard Mitigation, and Land Use Conversion Programs
G Flood Disaster Relief Programs
H Floodplain Wetland Restoration Policies
I Agricultural Support Policies Related to Floodplain Use.

The basis for the evaluation in each case is to assess how the impacts of the 1993 flood might have been different if specific policy and program measures had been in place at the time of the flood. It is understood that this will not necessarily provide a complete perspective on all aspects of any given measure being analyzed, but a substantial amount can be and has been learned by approaching the analytical tasks in this way.

It is important to recognize that many of the measures are quite conceptual in nature and difficult to evaluate, because databases and other information have not been collected and organized in a manner that responds to many of the questions that implementation of a measure would raise. Therefore, a substantial amount of judgment is involved in identifying the most significant aspects of these measures, and a great deal of reliance has been placed in many cases on consultations with officials in other agencies at both the Federal and State levels in gaining insights as to the likely impacts that could result from implementation of these measures.

Summary impacts matrix tables for Scenarios 1, 2, and 3, showing cell entries of potential changes in impacts for the measures considered in the respective policy and program categories, are shown at the conclusion of this chapter. More detailed discussion and analysis of the scenario measures, and explanations of cell entries, are contained in Appendix B (Evaluation) to this report.

The policy and program evaluations are based almost entirely on the features of the individual measures that were analyzed. Many of the measures did not result in identifying potentially large changes in impacts with reference to the 1993 flood. Nevertheless, it is certainly possible to formulate many different combinations of these measures in ways that might lead to significant changes in impacts, especially for flood events less severe than the 1993 flood. This step went beyond what could be accomplished in this assessment. The analysis presented in this chapter, however, can serve as a starting point and certainly invites more detailed consideration of various floodplain management policies and programs to determine what changes could be of greatest importance for specific conditions and locations, both locally and systemically.

National Flood Insurance Program Regulations

The National Flood Insurance Program (NFIP) is one of the critical tools in effective floodplain management. From its inception with the enactment of the National Flood Insurance Act of 1968 through Title V of the Riegle Community Development and Regulatory Improvement Act of 1994 (Public Law 103-325), the program goals have been:

1. to increase the awareness of the dangers and risks of floodplain habitation;

2. to reduce or minimize individuals and communities at risk by means of wise floodplain regulations; and

3. to internalize the costs of floodplain occupancy, thereby reducing the reliance on Federal disaster relief expenditures.

If nothing else, the great Midwest flood of 1993 exposed the weaknesses and strengths of a proactive flood insurance program. Local, State, and Federal floodplain management and disaster officials have coalesced into a force for change in pre-disaster planning and post-disaster recovery. While many of the flood insurance reforms of Public Law 103-325 have been discussed for years, it is unlikely that major changes could have been effected without the riveted national attention on the prolonged agony suffered by the citizens of the Midwest in 1993.

Though Title V of Public Law 103-325 implements important improvements in mitigation insurance, mitigation funding, lender compliance, and a 30-day waiting period in the NFIP, other crucial issues remain.

Market Penetration: What other strategies in addition to increased lender compliance can expand the number of policies in force to levels approaching the potential market? Is a more punitive approach for non-participation the only effective option or is there some blend of a positive inducement to behavioral change?

Repetitive Losses: Repetitive losses, primarily in the pre-Flood Insurance Rate Map (FIRM) floodplains, exert undue pressures on the actuarial viability of the NFIP. While estimates vary, it appears that 2 percent of the policies have historically accounted for 25 to 50 percent of the claims and a similar proportion of the dollars paid out from the National Flood Insurance Fund. Likewise, damages per pre-FIRM structure on average are three times the damage to regulated floodplain structures. The inclusion of a cumulative damage criterion to the existing substantially damaged criterion and targeted buyouts would eventually remove this significant drain on the NFIP. The definition of "repetitive loss structure" contained in Section 512 of the NFIP reform legislation should help in addressing these problems.

Expansion of Areas Requiring Flood Insurance: Recognition of the potential for catastrophic flood damage in areas within or protected to the Standard Project Flood (SPF) would increase the public awareness of flood risk. It would also indemnify the Federal Government against the potential for "budget-busting" disaster payments. Actuarial based premiums in the expanded coverage areas would reflect the appropriate risk depending on the level of protection or location in the floodplain.

The Federal Emergency Management Agency (FEMA) has commented that some caution should be used when considering the definition of "floodplain location." Many of the buildings that were flooded that were outside the 100-year floodplain were in the City of Chicago or in Cook County, Illinois, and had basements flooded due to backup of combined storm sewer systems. Other areas also had buildings with basements that were flooded due to sewer backup, inadequate storm sewers or other drainage problems or high groundwater (some of it behind levees). These types of problems do not lend themselves to floodplain mapping. For the Midwest flood, only 2,483 out of 16,167 claims filed (15.4 percent) were in B, C, and X zones (outside the 100-year floodplain). Note that B, C, and X zone buildings as a class are actuarially rated and not subsidized.

Community Rating System (CRS): The Federal Emergency Management Agency has commented that the NFIP Community Rating System provides for up to a 40 percent discount in flood insurance premiums for communities based on its class rating. Currently, the highest rated community is a Class 5 and receives a 25 percent discount. The discount is limited to 5 percent (Class 9) only for the first year of participation. Applying for the CRS requires some effort on the part of a community, but discounts of up to 10 percent can probably be obtained with minimal cost to the community. Over 800 communities currently participate in the CRS, accounting for 56 percent of all NFIP policies. The current low level of CRS participation in the Midwest is probably due to the low number of NFIP policies in most communities. The seven-State region as a whole accounts for less than 2 percent of the NFIP policies nationwide. Many of the Midwest communities probably could receive at least the 5 percent discount based solely on implementing more restrictive State floodplain management requirements and low cost public awareness activities that they may already do. However, they probably do not view it as worthwhile to go through the application process since so few people would benefit from the premium discount. The CRS is fully funded and fully available to communities that apply.

The environmental work group concluded that implementation of NFIP regulations under scenarios 1, 2, or 3 would have negligible or no impact on all environmental impact categories (wetlands, forest, threatened and endangered species, extent of floodplain inundation, public lands, recreation sites).

From a cultural resources perspective, there is concern that tightening flood insurance requirements could lead to evacuation of historic structures or make them more subject to flood mitigation measures that would harm their historic value. On the other hand, if these measures served to discourage future floodplain development, there could be a positive benefit to archaeological resources of the floodplain.

A more detailed discussion of the individual measures considered under each of the scenarios for National Flood Insurance Program regulations is contained in Appendix B (Evaluation) to this report.

Summary: The most significant point to be made in considering NFIP provisions through the evaluation framework matrix table is that an expansion of the program, especially with respect to the numbers of participants, would result in a reduction in the need for Federal disaster assistance. It would also help to assure that those who invest and live in the floodplain accept appropriate responsibility for flood damages when they occur. Provisions contained in Title V of Public Law 103-325, the National Flood Insurance Reform passed into law in 1994, are directed toward achieving these objectives.

State Floodplain Management and Zoning Practices

To determine how potential changes in State and local floodplain management and zoning practices might have affected the flood damages experienced during the "Flood of 93," we attempted through available data and original interviews to review five measures that deal with State floodplain management and zoning practices, and three measures that deal with local floodplain management and zoning practices. The measures are components of the three Floodplain Management Assessment (FPMA) scenarios.

Overall, mitigation activities (acquisition, relocation, or demolition) and structural protection have the highest potential to affect damages experienced during the 1993 flooding. Mitigation activities appear to excel in the 1993 flood experience because they physically eliminate the risk of flood damage through the removal of structures from harm's way. This approach is effective only to the "design level of protection" (i.e., an acquisition project that clears the 100-year floodplain does not prevent damages in the 500-year floodplain). Similarly, zoning will be effective only for the floodplain area being regulated, which typically is at or below the 100-year flood elevation while the 1993 flood exceeded a 100-year flood in many locations. In many respects, however, the damages incurred from the 1993 flood could have been much worse were it not that six of the seven States examined have had floodplain management programs for a number of years; initial floodplain mapping has been completed; and most communities with flood problems have adopted and are enforcing floodplain management ordinances that meet both NFIP and State minimum standards.

The following is a brief review of how each State acted on its floodplain management policy by the time this report was drafted.

- Illinois uses a State-produced model floodplain development ordinance fashioned after building code ordinances as the basis for its floodplain management program. The State issued a new rule on levee repairs after the 1993 flood, and amended an administrative rule in the spring of 1994 requiring project sponsors to analyze the impacts of all new levees to the top of their freeboard versus the 100-year flood elevation.

- Iowa has had an active floodplain management program since 1957, and has not made any policy or program changes since the "Flood of 93".

- Kansas has not passed any new legislation as a result of the "Flood of 93".

- Minnesota has had an active floodplain management program since 1969, and has not enacted any new legislation related to floodplain management since the "Flood of 93".

- Nebraska has had an active floodplain management program since 1967, and has not made any changes in the program since the "Flood of 93".

- Wisconsin has had an active floodplain management program since 1965, and has made no changes to its zoning policies as a result of the 1993 flooding.

We examined each measure in terms of potential for the following categories of impact: Flood Damage Change; Government Expenditure Change; Change in Floodplain Resources; Critical Facilities; Protection/Avoidance of Harm; Social Well-Being; and Implementation Costs. The review produced evaluations of the effectiveness of the measures on a subjective scale: none, low, moderate, or high impact because available data could not support specific dollar amounts of reduced damages to individual measures. The following discussion summarizes the measures we evaluated, with emphasis on potential to produce impacts greater than the none or low categories. For more discussion of the rationale for assigning the impact ratings, refer to Appendix B (Evaluation).

Scenario I Impacts

A. Management Measure: Variety of State policies and programs assumed to continue without major change (Scenario 1).

The objective of this measure is to identify State floodplain management policies and programs, and any changes that have been implemented since the "Flood of 93," as well as the impact of these changes.

1. Changes in State floodplain management policies and programs have generally not been introduced since the 1993 flood, primarily because substantial programs are already in place. In Missouri, a decrease in flood damages ultimately could result with passage of legislation establishing a State floodplain management program incorporating recommendations in the Governor's Task Force on Floodplain Management report.

2. An important, continuing need at both State and local levels is large-scale floodplain mapping to assist in more effectively administering existing floodplain management policies.

B. Management Measure: Increase funding for flood hazard mitigation planning to as much as $1.5 million annually.

The objective of this measure is to provide another funding stream for mitigation planning to help State and local floodplain managers avoid impacts associated with major flood events. The funds would be available to create and update plans, but not to execute actual flood hazard mitigation measures.

Overall, this measure is judged to have a relatively low impact (reduction) on floodplain damages because of the limited amount of funding provided by the program when compared to the number of communities requiring mitigation plans. According to the NFIP Community Status Book, 5 December 1994, approximately 3,972 communities are located in flood hazard areas in the seven-State region under study. FEMA has commented on this measure that it anticipates funding considerably more than 30 plans per year. Plans will largely be developed using local resources and will not require a high level of funding. It is also anticipated that only a relatively small percentage of NFIP participating communities have enough buildings in the floodplain to be motivated to develop a mitigation plan. For example, of the over 18,500 communities participating in the NFIP, less than 800 in the Nation and 128 in the seven Midwest States examined in this assessment have 10 or more repetitive loss properties. Realistically, these communities are likely candidates for mitigation plans. Many of the 3,972 communities in the seven States have no development or only a few structures in their flood hazard areas and are not likely to be interested in developing a mitigation plan or to be funded. Finally, a number of the communities with significant flood hazards have already completed mitigation or floodplain management plans using their own resources.

Scenario II Impacts

C. Management Measure: Locational requirements and contingency planning requirements for critical facilities are tightened to avoid the standard project flood (SPF) or provide protection against the SPF.

The objective of this measure is to reduce the risk to critical facilities by increasing the structural protection around these facilities and tightening siting requirements for future facilities within the floodplain.

This measure proposes the structural protection of all existing hazardous materials production, storage and waste facilities, and essential utilities to meet the SPF, or the relocation of these facilities and siting of new facilities outside the SPF.

1. There will be a high reduction (100 percent) in the number of critical facilities with harmful releases at risk from flooding if all of the facilities are protected to the SPF.

2 The number of other critical facilities at risk would be only moderately reduced because the measure presumes to require SPF protection only for hazardous materials production, storage and waste facilities, and essential utilities. Essential and emergency services facilities would remain at risk from flooding.

3 The implementation costs associated with planning, designing and constructing structural protection for all of the hazardous materials production, storage and waste facilities, and essential utilities in the seven-State FPMA study area to meet the SPF will be very high.

D. Management Measure: Community Development Block Grants (CDBG) through the Department of Housing and Urban Development (HUD) are provided which finance relocations in NON-DISASTER situations, once cost sharing requirements are met by State/local governments.

The objective of this measure is to provide States and communities with another funding stream to be more proactive in acquiring and relocating flood prone facilities prior to a disaster. (These grants are currently available for the acquisition and relocation of facilities through supplemental appropriations that occur after a natural disaster. The CDBG program is not currently a cost-sharing program. Funds are distributed to the requesting States and communities with no requirement for matching funds. The measure proposes to change this to a cost-sharing program, most likely at the standard Federal match of 75 percent Federal and 25 percent local.)

1. The benefits of mitigation activities such as acquisitions, relocations and demolition are high regardless of the funding source, because these activities eliminate the risk to structures associated with flooding. The impact assessment reflects the benefits of funding mitigation activities in general. It does not necessarily indicate that the CDBG program, or a changed program, is the best way to fund mitigation activities. Further analysis of the ramifications associated with changing the CDBG program would be required to determine whether it would provide the best mechanism for non-disaster mitigation funding.

2. There will be a low reduction in the number of critical facilities at risk as a result of providing CDBG funding for acquisitions and relocations in non-disaster situations. A large percentage of these facilities are location dependent, and cannot easily be relocated.

Scenario III Impacts

E. Management Measure: State governments as well as Federal agencies are also required to meet the standards contained in Executive Order (E.O.) 11988.

The objective of this measure is to encourage States to be more responsible for floodplain management by directing all of their agencies to:

- avoid directly or indirectly supporting floodplain development;
- avoid actions located in or affecting the floodplain, unless the floodplain location is the only practicable alternative; and
- in the absence of a practicable alternative, require that actions be designed or modified in order to minimize potential harm to or within the floodplain.

1. This measure will encourage State governments to more closely follow and assess the impacts of their actions on the floodplain. It will, however, only regulate floodplain development funded with State monies, not development which is funded by private citizens and corporations.

2. Because the E.O. will only regulate State funded development in the floodplain and does not address the flood damage risk to existing facilities, the impact rating is low.

3. This measure may affect the viability or development costs of private projects in the floodplain. Private development would be affected to the extent that public services or utilities would be limited.

4. The Governor of Wisconsin signed E.O. 132 in 1992, establishing floodplain management guidelines for State agencies and creating a flood hazard interagency coordinating committee. The E.O. requires all State agencies

proposing to construct new facilities in the 500-year floodplain to go through an eight-step decision process to document impacts and lessen the risks of losses to floods. The E.O. also stipulates that public facilities, including additions to existing facilities which will be owned or leased by the State, may not be constructed in the 100-year floodplain unless there is no practicable alternative. Critical facilities which will be owned or leased by the State may not be constructed in the 500-year floodplain unless there is no practicable alternative.

From an environmental resources perspective, there were no significant changes in resources identified for the measures under Scenarios 1 and 2. Positive impacts are attributed to the measure requiring State compliance with standards identified under E.O. 11988.

From a cultural resources perspective, none of the measures examined would appear to have an overriding impact on historical or archaeological resources. Increased flood hazard mitigation planning could assist in identifying historic or archaeological sites.

Summary: The State floodplain management measures examined in this assessment which appear to have the greatest potential impact in reducing damages from the 1993 flood, using the evaluation framework matrix, are those involving tighter regulation in the location of critical facilities and increased funding to State governments to pursue more flood hazard mitigation projects. Otherwise, the fact that six of the seven affected States have had active floodplain management programs for years helped reduce flood damages and social impacts from the 1993 flood to levels below which they otherwise would have been.

Local Floodplain Management and Zoning Practices

Scenario I Impacts

A. Management Measure: No major changes in local floodplain management and zoning trends; standards for participation in National Flood Insurance Program (NFIP) generally adhered to.

The objective of this measure is to identify local floodplain management policies and programs, and any changes that have been implemented since the "Flood of 93," as well as the impact of these changes.

1. Eighty-nine communities have implemented floodplain zoning ordinances or otherwise adopted requirements for permits regulating floodplain development in order to qualify for the NFIP program since the "Flood of 93." The State of Iowa showed the greatest increase in participation, with 41 communities implementing new programs to participate in the NFIP. This represents a 2 percent increase in the total participation of the 3,972 communities identified as being in special hazard areas. Nearly all the other communities with significant flood hazard areas in the Midwest States affected already participated in the NFIP prior to the flood.

2. The local communities that were contacted in conjunction with this study have not made any nonstructural (zoning) policy changes since the "Flood of 93." However, they have been aggressively pursuing buyout programs and mitigation planning to help avoid future damage during flooding conditions.

Scenario II Impacts

B. Management Measure: Community Rating System (CRS) features are promoted; reduced premiums for structures in participating communities are increased from the current 5 percent discount to as much as 20 to 25 percent.

The objectives of this measure are to increase individual participation in the NFIP and to induce more communities to exceed minimum NFIP floodplain land use management requirements by providing NFIP policyholders with higher reductions in premiums than are currently available under the CRS.

1. The potential impact of the present CRS program is rated low. In general, communities contacted about the CRS program were either not familiar with the CRS or felt that it was not cost effective for them to participate. Their main concern was that they would have to carry the financial burden of providing the programs and protection required to be eligible for the program but would not receive the benefits the program offered to individuals. From this point of view, they did not see how they could fund these programs without passing on the costs to the ratepayers, which would eliminate the benefits they receive from the program. FEMA has indicated, as previously discussed, that many communities in the Midwest could qualify for 5 or 10 percent discounts based on activities they already do, but an application has to be prepared. An explanation for the relative lack of interest appears to stem from the low number of NFIP policies in effect that makes this effort less attractive in the Midwest than in other parts of the Nation with more floodplain development. There may not be an adequate understanding that the "payoff" for implementing CRS measures is that they contribute to flood damage reduction, reduced public expenditures for emergency services, improved protection of infrastructure, etc., over time.

2. The communities that are currently participating in the program did feel that the increased NFIP premium reductions would provide an incentive for individual property owners to purchase flood insurance and pressure local governments to qualify for even higher premium reductions. More widespread participation in flood insurance would lead to better floodplain management programs within these communities.

3. Communities have to develop and fund programs to qualify for CRS discounts but do not receive any return on their investment if only policyholders receive the discounts. While this perception exists, the number of communities participating in the program will remain low.

4. Small communities might have to commit a significant portion of their budget to meet the program requirements, while large communities might already meet many of the requirements without additional effort.

Scenario III Impacts

C. Management Measure: Communities are required to obtain private insurance to cover flood losses to public facilities in order to receive supplemental post-flood disaster assistance.

The objective of this measure is to shift the fiscal responsibility for floodplain management and damages to public facilities away from the Federal Government.

1. The initial review of this measure suggested that, because it does not appear to increase protection levels, the potential impact of this measure is rated low. FEMA observes, however, that this requirement would probably increase protection levels, because the cost of insurance is based on the risk of exposure. Local units of government may have a greater incentive to protect those facilities at risk in order to avoid or reduce the costs of insuring them. Also note that there is already a deductible in the Stafford Act for infrastructure assistance for buildings that is equal to the amount of flood insurance coverage that the community could have purchased.

2. Private flood insurance for public facilities seems to be an idea that has caught on with a number of the communities contacted. In the case of the Des Moines, Iowa, Waterworks, private insurance saved taxpayers approximately $9.9 million. In order to retain its private insurance coverage at affordable rates, the Des Moines Waterworks upgraded its levee and took other mitigation measures after the 1993 flood.

3. Losses to public facilities were high in relation to total post flood disaster expenditures. FEMA expenditures for infrastructure nearly equaled those for human services.

There were no significant environmental resources identified that would likely be affected by any of these measures. For cultural resources, there are concerns that some of these policies might discourage retention of historic buildings. But if floodplain development is inhibited, archaeological resources could be benefited.

Summary: None of the local floodplain management measures examined in the impacts matrix table were evaluated as having potential to make a large quantitative impact with respect to the 1993 flood event. Nevertheless, actions such as those examined, when taken at the local government level, are recognized as important tools in improving floodplain management and in reducing future exposure to flood damages. The most effective approach in some locations may be to ensure that adherence to existing regulations under the NFIP is achieved at the local level.

Community Relocation, Flood Hazard Mitigation, and Land Use Conversion Programs

A more detailed discussion and analysis of policy and program measures in this category are presented in Appendix B (Evaluation) for this report. Significant findings and results from the analysis that has been completed are summarized below for the main report. Reference is made to Column F of the impacts matrix summary tables (scenarios 1, 2, and 3) for the change of impact information related to these measures. The basis for much of the information obtained in the review of these policy and program measures was a series of telephone interviews with State government officials responsible for floodplain management or emergency response services in the Midwest States covered by this assessment.

Scenario 1 Measures

Three measures have been identified for this scenario that represent changes in flood hazard mitigation policies and programs since the Midwest flood of 1993. They are: 1) FEMA buyouts of 5,000 or more substantially damaged structures; 2) increased funding from NFIP premiums up to $20 million annually for a national flood mitigation fund (part of Public Law 103-325); and 3) increased Federal cost share for hazard mitigation and relocation from 50 percent to 75 percent (part of Public Law 103-181).

These measures represent a significant change in emphasis from past patterns of recovery from major floods. It is evident that acquisition and removal of substantially damaged structures is growing in preference as compared to restoration of flood prone areas to pre-flood conditions. While the up-front costs to complete acquisitions are significant, there are long-term advantages by way of future costs avoided for repetitive disaster assistance, insurance payments, improved public health and safety, and reductions of social disruption and emergency response costs. The State of Missouri, for example, in its use of Federal mitigation funding assistance after the 1993 flood, has focused solely on acquisition and relocation of substantially damaged structures as the strategy to minimize future exposure to repetitive flood damage.

Based on data supplied by FEMA Region V and VII offices, FEMA Headquarters, and additional information provided by State agencies, 8,251 parcels have been approved for mitigation projects. Most are for acquisition of substantially damaged residential structures. These involve 177 sites. Total approved cost is $205 million, of which $4.1 million is from the NFIP's Section 1362 program, $67.1 million from CDBG's, $21.5 million from the Economic Development Administration (EDA), and $105.6 from FEMA's Section 404 Hazard Mitigation Grant Program. Based on project justification procedures, it is judged that at least this amount of damage could have been avoided to residential and other urban structures if these projects had been completed prior to the 1993 flood. Sizable reductions in emergency response costs, disaster relief, and flood insurance payouts could also have been realized if the acquisitions now being pursued had been completed prior to the 1993 flood.

Both the prospective increase in mitigation project funding and the increase in Federal cost sharing for mitigation projects to 75 percent indicate that a continued emphasis will be placed on actions that will remove or reduce exposure to future flooding. Note also that Public Law 103-181 significantly increased the amount of funding available by changing the formula to 15 percent of FEMA assistance for human services assistance and infrastructure assistance less administrative expenses. There is recognition of the need and support for strengthening State and local floodplain management capabilities to address areas with repetitive flooding problems through mitigative actions, and to guide new development to locations that will avoid or minimize exposure to future flooding. The prevailing view is that funds spent on advance mitigation planning and mitigation projects should result in much greater reductions in future flood damages and disaster payments.

Scenario 2 Measures

Two measures have been identified for this scenario in this policy/program area. They are: 1) discontinue Federal leases of floodplain areas for cottages and other private uses; and 2) ensure that flood hazard mitigation funds are made available as quickly as construction funding for repairs in place.

Over 1,100 private leases on Federal land in the upper Mississippi River floodplain are still in effect. More than half (653) are in Illinois. As the result of the severity of the 1993 flood, approximately 100 leases were not renewed by leaseholders. For others, however, disaster aid and national flood insurance payments were received, despite language in the standard lease contract prohibiting such claims against the Government. There are clearly conflicting guidelines among Corps of Engineers, FEMA, and other agencies concerning treatment of these leased properties. It is inconsistent to encourage actions by governments and the private sector that will lead to avoidance of exposure to damaging floods while at the same time subsidizing private citizens for a privileged access and residential use of Federal land in the floodplain with known, repetitive flood risk. The problem is compounded because some of these cottage sites, instead of being for temporary, recreational use, have been upgraded to permanent home sites. Annual lease payments are in the range of \$500 to \$600.

This measure has potential to make a sizable reduction in the overall amount of Federal disaster aid and insurance payouts that would be required for a comparable future flood event. FEMA comments that lease sites may constitute the single greatest repetitive loss structure category. Some of these structures are valued at \$15,000 and have received as much as \$100,000 in flood insurance claims and additional disaster assistance benefits in the last 15 years. The effect of a measure to end private residential use of Federal land in the floodplain would meet several important objectives, including reductions in property damage, emergency costs, disaster aid, insurance payouts, and exposure of risk to life and health from major flooding. It would also be consistent with what citizens elsewhere have been encouraged to do in other residential areas on privately owned lands that suffered extensive flood damage.

The concept of making the option of flood hazard mitigation funds available as quickly as construction funds for repairs in place to substantially damaged homes is considered very important by floodplain management and emergency response officials. Otherwise there can be a temptation to "shop around" among the Federal disaster aid programs to obtain the fastest assistance, even if the result is to complete repairs that leave people vulnerable to repetitive flooding.

FEMA comments that the 1994 NFIP reform legislation authorizes the agency to provide coverage in the flood insurance policy for the cost of bringing buildings into compliance with local floodplain management regulations (mitigation insurance). This coverage should be in effect for new and renewal policies beginning on October 1, 1996. Payments would be made through the flood insurance claims adjustment process. If this coverage had been in effect prior to the 1993 Midwest flood, several thousand buildings would have been elevated, demolished, relocated, or floodproofed in the few months after the flood. The NFIP reform act defines repetitive loss structure as one incurring 50 percent or more cumulative damage if flooded twice within a 10-year period and includes such structures as eligible for mitigation insurance coverage. With these reforms in place, it is evident that in some situations it will lead to acquisition and removal of substantially damaged structures instead of repairs to houses at high, repetitive flood risk.

Scenario 3 Measure

The only measure considered here is for cost shared funding, by the combination of Federal, State, and local governments, to be made available to acquire all structures repeatedly and substantially flooded. The Interagency Review Committee report (June 1994, Table 8.1, p. 126) identified more than 5,700 structures in the National Flood Insurance Program in the nine Midwest States that were repetitively damaged over the period 1978-1993. More than 57 percent of these structures are in Missouri. There are undoubtedly other structures with repetitive flood problems that are not a part of the flood insurance program. The priority for this measure would be on those structures that are a part of the NFIP.

It would appear that many of these structures are under consideration in the large number of flood mitigation projects currently being reviewed and implemented. More specific information relevant to this measure may be developed over time as a number of the Midwest States and communities complete more detailed hazard mitigation plans. There is no reliable quantitative data available of the potential cost to expand mitigation projects involving acquisitions over time. The 1993 flood provides a perspective for what the additional costs might be, as well as the potential for reducing future emergency response and disaster relief costs associated with areas experiencing substantial, repetitive flooding.

The only measure in this policy/program category identified as significantly affecting environmental resources of the floodplain is the Scenario 3 measure for pursuing buyouts of all substantially damaged structures. A positive impact on public lands and number of recreation sites was noted. From the cultural resources perspective, there is concern that actions to mitigate or relocate structures could harm historic resources.

Summary: Several of the flood hazard mitigation measures examined would have had a significant impact had they been in place at the time of the 1993 Midwest flood. Acquisition of properties known to be at risk of repetitive flooding has already led to removal of structures that otherwise would have been substantially damaged once again in Missouri as of the time of this writing in mid May 1995. The increase in Federal cost share for mitigation projects from 50 percent to 75 percent, on par with the standard Federal cost share for disaster assistance, is important; even more important is the change in the FEMA funding formula that allows 15 percent of all FEMA disaster assistance to be applied to the Hazard Mitigation Grant Program. The increasing emphasis on mitigative approaches in flood disaster response represents a significant shift in action from the historical emphasis on restoration of flooded areas in kind and in place as quickly as possible. The result should be reductions in the need for and amount of future Federal disaster assistance in areas known to be at risk of repetitive flooding.

Flood Disaster Relief Programs

As with the previous section, a more detailed discussion of flood disaster relief measures is presented in Appendix B (Evaluation) to this report. Significant findings and results from the analysis that has been completed are summarized below for the main report. Reference is made to Column G of the impacts matrix summary tables (scenarios 1, 2, and 3) for the change of impact information related to these measures. The basis for much of the information obtained in the review of these policy and program measures was a series of telephone interviews with State government officials responsible for floodplain management or emergency response services in the Midwest States covered by this assessment.

Scenario 1 Measure

The only measure considered here is continuation of existing Federal agency disaster relief programs. This measure prompted not so much a review of possible changes in impacts from flooding but an opportunity to suggest what could be improved. The general reaction is that the Federal disaster response was more effectively provided for the 1993 Midwest flood than for prior large-scale natural disasters.

The formation of interagency recovery groups or task forces involving both State and Federal agencies, and the functioning of the FEMA Interagency Hazard Mitigation Teams, proved to be valuable in improving coordination and delivery of services and should be continued in conducting future post-disaster response actions. There is a desire for more flexibility and discretion at the State and local levels in determining how disaster relief funds can best be applied. Other suggestions include the need for a single environmental review standard and process in implementing disaster relief and flood hazard mitigation projects; a single buyout program community application instead of separate applications for FEMA and HUD; and a broader consideration of non-quantifiable impacts to social welfare, health, and community well-being needs in determining the justification for hazard mitigation projects that go beyond what is currently considered in benefit-cost analyses for these projects.

Scenario 2 Measures

Two measures are considered in this scenario. They are: 1) all disaster assistance is strictly cost shared at 75 percent Federal/25 percent non-Federal and made consistent across all Federal relief programs; and 2) public assistance grants to communities not in the National Flood Insurance Program are greatly reduced.

The first measure reflects the concern that the Federal Government is assuming more and more responsibility over time for disaster recovery costs. Disaster assistance has become a Federal program and benefit that unfortunately has come to be looked upon as an entitlement. In the process, there may be a "disincentive" for State and local governments and individual citizens and businesses to take appropriate advance planning, mitigation, and insurance decisions to better avoid or cover the risks of extraordinary flooding. When the Federal Government increases its cost sharing burden to greater than 75 percent, this serves to raise expectations of how recovery costs for future disasters will be treated. A recent pattern, for the largest disasters, at least, is that States claim they cannot afford the required 25 percent State/local cost share and request the Federal Government through FEMA to assume 90 to 100 percent of the disaster costs. The view has been expressed, even by State officials, that the focus should shift from "How do we obtain even more Federal disaster funds?" to "How do we improve our floodplain management and mitigation programs to avoid future flood damages?".

If the 75 percent limit to the share of emergency response and recovery costs of ALL the Federal agencies (not just FEMA) had been applied during the 1993 Midwest flood event, it is estimated that a reduction of Federal expenditures on the order of $375 million might have been realized. The real objective of the measure, however, is not simply to reduce Federal expenditures, but also to encourage greater emphasis on flood hazard planning and mitigative actions that emphasize avoidance or minimizing of exposure to repetitive flooding problems. This responsibility is recognized as needing to be assumed to a greater extent at the State and local government level and by businesses and households in the private sector. A State agency comment noted, however, that a strict 75 percent Federal cost share might well have resulted in fewer acquisition and relocation projects being completed.

In a similar manner, limiting public assistance grants to communities who are not enrolled in the National Flood Insurance Program is intended to prompt greater attention to potential flooding problems in those communities not currently enrolled. Otherwise, it "rewards" communities who fail to take actions to protect themselves from repetitive flooding problems if they receive disaster aid to the same extent as communities who have taken steps to obtain insurance and meet other NFIP standards. Sometimes the problem is not recognized or confronted until a request for a Federal disaster declaration is NOT approved, and the local community and State are faced with the costs of recovery on their own.

State agency officials are supportive of this concept and yet recognize that most States are doing relatively little on their own at this time to formally review or require compliance with NFIP standards. There appears to be little follow-up by way of funding, monitoring, or enforcement to ensure that recommendations of the FEMA Interagency Hazard Mitigation Team reports subsequent to Federally declared disasters are implemented. One suggestion is to link other State funding allocations to local communities based on how well communities address repetitive flooding problems. Data was not obtained that would allow an estimate to be made of how many emergency response and recovery dollars were provided to non-participating communities in the aftermath of the 1993 flood. If this measure were taken, there would presumably be an increase in insurance protection purchased by local communities for their public facilities at risk of flooding, and a heightened sensitivity to plan future community development in ways that avoid increasing exposure to flood risk.

Scenario 3 Measures

Two measures are included here: 1) post flood disaster relief is eliminated for communities and individuals within designated STANDARD PROJECT FLOOD outline areas not participating in the National Flood Insurance Program; and 2) repeat flood DISASTER payments to individuals and communities are eliminated.

These measures are directed at greatly expanding the definition of areas at risk of flooding and greatly penalizing those individuals and communities who fail to ensure continuous participation in the NFIP despite being located in areas of repetitive flooding. The first measure would require a much enlarged national flood insurance program and mapping effort. The feeling of many State officials is that there are enough challenges to improve the mapping, increase participation, and ensure compliance with existing NFIP requirements. A more important step to be considered at this time should be to focus attention and pursue mitigative actions on repetitive loss situations within the 100-year flood risk zone.

The second measure was also considered quite extreme and too arbitrary. There is support for the concept of tying disaster aid to the development and implementation of flood mitigation plans that deal with chronic flood problems at the local level.

While Federal disaster relief and emergency response expenditures could be significantly reduced under this scenario, there would be a substantial increase in mapping costs necessary to implement the first measure, and a shifting of disaster response costs to State and local governments and the private sector with both measures.

There were no environmental floodplain resource changes attributable to the measures examined in this policy/program category. There was concern that, with the potential for reduced disaster assistance, historic resources might be detrimentally affected.

Summary: The flood disaster relief measures that were examined are of some importance as tools to be considered in responding to flood damages. To the extent that more of the financial responsibility for flood disaster relief is shifted from the Federal Government to other levels of government and the private sector, incentives may be created that will lead to approaches emphasizing avoidance of flood damages instead of responses to flood losses after they occur. To the extent that greater reliance on flood insurance coverage by individuals, businesses, and communities is encouraged, there will be less need for extraordinary flood disaster related expenditures. Damages would be covered more on a "pay as you go" basis, which is what insurance is designed to accomplish. The changes in Column G of the impacts matrix tables show this change in emphasis, with reductions in disaster expenditures relative to the 1993 event but increases generally in insurance payouts. Therefore, applying stricter standards in qualifying for flood disaster assistance; limiting the amount of disaster assistance; and encouraging greater participation in flood insurance programs instead of reliance on disaster relief may all be useful tools in placing greater responsibility in the hands of those who gain advantages from their floodplain location. This would especially be the case in areas known to be at repetitive flood risk.

Floodplain Wetland Restoration Programs

Introduction

Six measures in the Floodplain Wetland Restoration Program issue area were examined as part of the Floodplain Management Assessment effort to consider "nonstructural" policy and program options that may reduce future damages and flood stages caused by extreme flood events like the one in 1993. This set of existing, modified, or new policies and programs was also reviewed in terms of floodplain land use changes that might offer a more optimal mix of floodplain outputs. The goal was to consider a range of floodplain and wetland restoration programs and was not intended to be exhaustive in scope.

Analytical Approach

Numerous reports and documents were reviewed to determine the major programs which exist to promote floodplain restoration. The Federal agencies involved in restoration activities were contacted to help develop general descriptions of the programs available, the extent of acquisitions/relocation, and the funding levels. Although an attempt was made to obtain data at the FPMA study reach or county level, most data were available by State. Assumptions used to extract floodplain specific information from these data are described under the discussion for each measure. Most of the specific data on various programs including acreages enrolled and acreage in the floodplain were provided by Natural Resources Conservation Service (NRCS) staff. The States involved in the analysis of these floodplain wetland restoration programs are: Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, and Wisconsin.

Many of the existing programs have been established with different primary goals, such as water quality improvement, waterfowl habitat enhancement, soil loss reduction, etc. It must be noted that not all individual wetlands provide all of the functions and related benefits attributed to wetlands in general. While the policies considered under this issue area deal mainly with "wetland" restoration, the actual flooding of the floodplain, as discussed in Chapter 3, is critical for the maintenance of the floodplain-river ecosystem and its associated natural functions and outputs. Thus, true natural "floodplain" restoration requires an establishment of the natural hydroperiod. The impacts of such structural modifications are discussed in Chapters 8 and 9, but should ultimately be considered in concert with the policy options discussed here.

Because land use changes are at the heart of the environmental impact categories, considerable effort was made to quantify acres affected, even though numerous assumptions often had to be made. These assumptions are described along with the estimates of effects and costs. Because of the spatial scale considered in this assessment, our environmental impact categories were chosen to simply show changes in wetland acres as the indicator of environmental health or integrity, realizing that a wetlands location and hydrology are the ultimate determinants of its function.

Scenario 1 Measure

A. Existing wetland protection and restoration policies assumed to continue without major change.

A brief description of the 21 programs in 12 different Federal departments, agencies, or services that were reviewed is included in the Evaluation appendix (Appendix B) to this report. Numerous other programs exist with local, State, national, or international scope that offer a wide range of opportunities for wetland protection and restoration. This analysis does not intend to diminish the importance of those programs but rather, because of the systemic approach and large study area constraints of the FPMA, only considers major Federal programs having both local and national impact.

The major Federal floodplain wetland restoration programs which result in direct conversion of land are administered by FEMA, the U.S. Department of Agriculture, and the U.S. Fish and Wildlife Service (USFWS). The major programs currently affecting large acreages of wetlands through protection or restoration are the Wetland Reserve Program (WRP), Emergency Wetland Reserve Program (EWRP), and Conservation Reserve Program (CRP).

Land use conversions after flooding due to FEMA mitigation, buyouts, and other existing programs result in increases in riverfront park, recreation, or wetland acreage. Acquisitions and relocations following the 1993 flood totaled nearly 6,000 (this number will likely continue to increase). If the acreage per property ranged from 0.2 to 0.75, total acres converted would range from 1,200 to 4,500. The end use of this land is for open space or recreational purposes, as regulated by the Volkmer Act of 1993. Such a conversion prior to 1993 would have had minimal effect on the 1993 flood event in terms of flood stage levels and damage reduction.

However, the major floodplain/wetland restoration or protection programs do not occur in urban areas, but rather in rural, agricultural areas. To estimate the number of acres of wetland that would be restored or protected under this measure, several assumptions were made. These are described below along with the estimates of acres affected and costs of implementation.

Wetland Reserve Program - Of the program goal of 1 million acres, 22 percent (based on existing sign-up) are assumed to be in the FPMA States. Fifty percent of enrolled WRP acres are assumed to be in the floodplain. These assumptions lead to approximately 105,000 additional acres restored if the program meets it goals. Of this amount, approximately 75 percent would revert to forested wetland and 25 percent would revert to non-forested wetland. Based on an average to date cost for this program of $907 per acre, a total cost of ~$95 million would be expected.

Emergency Wetland Reserve Program - NRCS data indicate that as many as 50,000 acres will be enrolled in the program. Wetland Restoration Plans have been prepared on 25,000 of these acres as of January 1995, and landowners are in the process of recording the easements on these acres. This leaves 25,000 acres yet to be enrolled. Program rules state that at least 75 percent of the land being enrolled must be "wetland." Under this measure of continuation of existing policy, it is estimated that an additional 18,750 wetland acres would be restored in the FPMA study area. Cost of the program is expected to reach roughly $50 million.

Conservation Reserve Program - The amount of CRP land already existing in the FPMA study area floodplain at the time of the flood was not readily obtainable. Thus, in consultation with NRCS staff and using estimates of flood prone cropland (see discussion for Agricultural Support Policies in Appendix B), it is assumed that at the time of the flood, 212,000 acres were enrolled. Since this scenario measure assumes programs continue with no change, no increase or decrease in CRP acres is estimated. Assuming that 10 percent of these CRP lands are wetland, 21,200 acres of wetland would continue to be protected. No acres are included in matrix table 1 because the tables only show changes. No additional costs would be incurred beyond existing costs.

Other Programs - As discussed above, there are a number of other current programs that have goals of restoration of floodplain and floodplain wetlands. Because of the difficulty in estimating acres enrolled in the floodplain, and specifically the FPMA study area, it was assumed that these additional programs would contribute 10 percent of the three major programs (EWRP, WRP, CRP). Under scenario 1, this would amount to approximately 23,000 acres. Costs were estimated assuming $1,500 per acre for agricultural conversion (King and Bohlen, 1994; NRCS, pers. comm.) resulting in ~$34 million.

Scenario 2 Measures

B. Increased funding for Refuge Revenue Sharing Act is provided to cushion local governments' tax base from land conversion effects.

Funding for this program comes from refuge receipts and from special Congressional appropriations. In some years, Congress has not funded the program, so the Fish and Wildlife Service has had to reduce payments. Only those lands within the Wildlife Refuge System, either through purchase or gift, are eligible for payments.

A residential/commercial test case to illustrate impact to tax revenues resulting from such land conversions is provided in Appendix B. Since most of the lands within the Wildlife Refuge System are outside centralized urban areas, it is expected that program impact to residential or commercial area conversion is insignificant.

A case study for farmland conversion is the Louisa County Levee District #8 buyout. The Fish and Wildlife Service added Iowa lands of approximately 3,000 acres, formerly known as Louisa County Levee District Number 8, to the Wapello District of the Mark Twain National Wildlife Refuge. To offset annual income received from county property taxes by previous landowners ($16,040), a revenue-sharing payment under the authority of the Refuge Revenue Sharing Act was proposed. The Environmental Assessment, dated April 1994, stated that a formula was used to calculate a full entitlement payment of $12,962. However, due to anticipated congressional appropriations for this program, payments would be reduced to 90 percent of full entitlement, or $11,666. The assessment states that "Although it appears that the county would lose tax money,...it is reasonable to expect that the county would adjust downward its assessed value of properties severely damaged by flooding."

While increased funding for this program will cushion local governments' tax base from land conversion effects, the payments to be made to these local interests are limited by the number of acres eligible for enrollment in the Wildlife Refuge System and will be mainly limited to rural areas. A broader program to minimize the impact of lost tax revenues resulting from land conversions would be beneficial and could reduce some of the opposition to these programs.

C. Stream and riparian restoration program established with Federal funding and technical assistance from the Department of the Interior (DOI), U.S. Department of Agriculture (USDA), and/or the Environmental Protection Agency (EPA).

Increased funding under this measure for administration, technical assistance, and acquisition will enhance existing programs or create a completely new program, and lead to a more coordinated Federal, State, and local restoration effort, possibly through goals established in interagency ecosystem management plans. There are numerous existing programs that deal with stream and riparian restoration, although most deal more generally with wetlands (see measure A above and Appendix B). This policy change would also involve a modification of the process for determining land acquisition priorities and procedures to acquire land, and assumes that targeted areas would be smaller streams and tributaries and not the main stem rivers that are the primary emphasis of this assessment. The Interagency Floodplain Management Review Committee Report (1994) discusses the importance of such a program (pgs. 95 and 109).

Riparian ecosystems are being degraded and destroyed throughout the United States. The lower 48 States originally contained 75 to 100 million acres of indigenous, woody riparian habitat, but today only 35 million acres remain in nearly natural condition (FIFMTF, 1992). The remainder have been inundated by reservoirs, channelized, dammed, riprapped, converted to agricultural use, overgrazed, paved, or altered by a combination of factors. These impacts have impeded their ability to stabilize and maintain the biological diversity of their own watersheds.

Because the amount of existing and potential habitat and the quality of that habitat is not known for the smaller rivers and streams that would be targeted by this program, we chose to assume that the budget for such a program would be similar to other national restoration programs, such as the Wetland Reserve Program. Ideally, the amount and priority of riparian habitat required to meet defined ecosystem management goals would be the basis for determining the costs required for such a program.

Assumptions for the WRP are based on the current eight-State FPMA study area sign-up of 22 percent of the total national program sign-up. This would allocate $220 million to the FPMA States, based on the estimated $1 billion WRP program costs, if the goal of 1 million acres protected is met. As stated above, this budget is hypothetical and was used simply to gauge the impact of the proposed program. Assuming the cost of restoration, easements, etc. is $1,000 per acre, this budget would result in 220,000 acres of riparian habitat protected or restored. Assuming a 100-foot buffer strip is the average width protected, approximately 9,200 river miles (24 acres per mile) could be affected by this program (slightly more than 1,100 river miles per State).

Since most of the stream habitat targeted by this program would not be in the FPMA base study area, the acres protected do <u>not</u> appear in the scenario 2 matrix table. However, it is estimated that 209,000 floodplain forest acres and 11,000 non-forested wetland acres would be protected or restored.

Riparian restoration would result in some economic benefits through prevented damages. However, indications are that the potential for damage reduction would be minimal for events similar to the 1993 flood. Although not specifically evaluated in this assessment, it appears that the economic benefits would accrue primarily from prevented damages during the more frequent events and would be localized in nature.

However, the major benefits of riparian restoration, especially on smaller tributaries and streams, as assumed here, are related to their ecosystem functions. Riparian habitats are unique in their linear form; they have very large energy, nutrient, and biotic interchanges with aquatic systems on the inner margin, and upland terrestrial ecosystems on their outer margin; they are connected to both upstream and downstream ecosystems; and they serve as important migration corridors. The fact that only 35 percent of the original riparian ecosystems in the lower 48 States remain intact today points out the need for a specific program directed toward their protection and restoration.

D. Floodplain wetlands targeted for priority enrollment in the Wetlands and Emergency Wetlands Reserve Programs.

This measure would direct more funds to floodplain wetlands in the Wetland Reserve Program than currently occurs. Since the EWRP specifically targets floodplain wetlands, there will be no change in acres protected with that program.

States have experienced an overflow of requests to enroll in this program. South Dakota, Illinois, Kansas, and Nebraska received no allocation in 1992 (first year of the program), so easement acres converted for these States preflood are zero. The 1994 allocation and program activity for the WRP was still with the Agricultural Stabilization and Conservation Service (ASCS) (now part of the Consolidated Farm Service Agency, CFSA). For Fiscal Year 1995, the Natural Resources Conservation Service (formerly the Soil Conservation Service (SCS)), is administering the program. Fund allocations and acres affected by the program are shown in Table 7-1.

The Emergency Wetland Reserve Program (EWRP) was authorized by the "Emergency Supplemental Appropriations for Relief from Major Widespread Flooding in the Midwest Act of 1993." Participation is limited to those States affected by the 1993 flood. The following criteria prescribe priorities for inclusion of lands submitted in the EWRP:

A. Protection and enhancement of habitat for migratory birds and wildlife, including the contribution the restoration of the land may make to threatened and endangered species.
B. Potential for floodway expansion.
C. Proximity to other protected wetlands.
D. Restoration potential of wetland hydrology.
E. Intrinsic wetland functions and values.
F. Potential for successful restoration of wetlands values.
G. Costs of easement acquisition and restoration of wetland functions.
H. Other relevant and/or nondescript considerations.

The initial emergency supplemental appropriation was $15 million to enroll approximately 25,000 acres. There were no expenditures in 1993. Funds are allocated by State. Total Fiscal Year 1995 allocation is $28 million but some of these funds may be pulled back. The cutoff date for applications under the EWRP was December 31, 1994. Applications approved as of February 1995 are shown in Table 7-2.

To estimate the number of acres of wetland that would be restored or protected under this measure, several assumptions were made. These are described below along with the estimates of acres affected and costs of implementation.

Wetland Reserve Program - Of the program goal of 1 million acres, 22 percent (based on existing sign-up) are assumed to be in the FPMA States. Because floodplain wetlands are "targeted" under this scenario 2 policy measure, we have increased the estimated percentage of enrolled WRP acres in the floodplain to 75 percent. This leads to approximately 157,000 additional acres restored if the program meets it goals. The cost would be ~$142 million based on current program expenditures.

Table 7-1
Wetland Reserve Program Allocations

FY	Allocation	Targeted Acres**	Acres Converted
92	$46 million	50,000	39,000 recorded
94	$66 million	75,000	none recorded yet*
95	$93 million	no cap (approx. 115-120,000)	
96	$230 million	(requested for 96)	

* Takes ~18 months to process from time the landowner applies. All appraisals are completed and commitments made, so recordation should start soon.
** Note that these are nationwide target acres.

Table 7-2
Emergency Wetland Reserve Program Applications

State	Applications Approved	Acres	Cost ($1,000)
Illinois	12	1,300	1,450
Iowa	380	34,000	27,000
Kansas	4	137	120
Minnesota	39	1,892	2,639
Missouri	143	15,540	11,266
Nebraska	10	200	170
South Dakota	25	4,185	1,745
Wisconsin	No applications received		
TOTAL	613	57,254	$44,390

Emergency Wetland Reserve Program - Since the EWRP already targets floodplain wetlands, no differences from scenario 1 would be seen. There is a potential to enroll 50,000 acres in the program and 75 percent or more of those acres must be wetland (under current program rules), resulting in a total of 37,500 acres (18,750 above what had already been enrolled and planned as of January 1995) at a cost of $50 million.

E. $2 million annual funding for land acquisition for habitat improvement under the Upper Mississippi River Environmental Management Program is provided.

This measure would expand the list of implementable solutions considered in habitat restoration planning under the Environmental Management Program (EMP) to alleviate habitat quality problems on the Upper Mississippi River. Habitat Rehabilitation and Enhancement Program

(HREP) Projects were authorized as part of the Upper Mississippi River System Environmental Management Program, under the Water Resource Development Acts of 1986 and 1990. These projects involve the expenditure of $150 million over a 15-year period (1988-2002) for habitat rehabilitation and enhancement on public lands that lie in and along the Mississippi River from St. Louis to Minneapolis-St. Paul, and the lower 80 miles of the Illinois River. The habitat projects are proposed by the States and the U.S. Fish and Wildlife Service, developed and designed by interagency planning teams, and engineered and constructed by the Corps of Engineers.

Although "acquisition of wildlife lands" was part of the original 1985 implementation framework for the EMP, land acquisition was only recently approved as an authorized habitat project component (31 Oct 94 letter from John Zirschky). All State EMP partners share a desire to consider projects that involve land acquisition (either as an incidental feature of a habitat project such as dredged material placement, or as a primary tool for restoration such as land conversion to floodplain habitat. It is not envisioned that one very large land acquisition project would be undertaken, but several projects that include smaller parcels. Acquisition would likely be done in conjunction with projects already in the EMP slate. Given this new initiative, a reprioritization of the remaining projects could result in improvement of the overall value of the full roster of EMP projects.

Land acquisition would be for fish and wildlife preservation, enhancement, or restoration and must include active construction and/or operation and management measures to improve the habitat value over the value in its current condition. Any flood damage reduction offered should be recognized as ancillary benefits.

To quantify the impacts from this policy measure, it was assumed that the policy was in place at the time significant project construction and funding for EMP began (1988) and that most acquisition occurred within the floodplain. This determination was based on discussions with HREP and EMP project managers and examples of HREP's with land acquisition components to date. It was also assumed that land was acquired at a 1:1 ratio of non-wetland to wetland. Although this is a smaller ratio than usually occurs for waterfowl habitat acquisition or land treatment programs, it was chosen based on the previous assumption that most acquisition would occur in the floodplain close to the HREP problem area. Average cost used per acre of non-wetland was $750 and of wetland was $300, based on averaging the costs shown for existing acquisition programs. Land acquisition was assumed to be cost-shared 75 percent Federal and 25 percent non-Federal, the same as current policy (thus providing $2.67 million total available funding). Under these assumptions, the acres that could have been purchased under this plan up to 1993 are ~5,000/yr or ~30,000 acres total (11,250 forested wetland, 3,750 non-forested wetland, and 15,000 non-wetland).

Scenario 3 Measure

F. New funding is provided to initiate a Lower Missouri River Environmental Management Program, with land acquisition for habitat improvement allowed.

This measure would expand the available Federal habitat restoration programs to alleviate Lower Missouri River habitat quality problems. There currently is no environmental management program for the Lower Missouri River like the one described above under measure E for the Upper Mississippi River. Many of the findings of the existing EMP as well as other large floodplain river studies would likely be expanded, applied and tested under a Missouri River EMP. Some of these findings have been discussed by the Environmental Management Technical Center (EMTC) (1994), summarized by Welcomme (1994) and reinforced by Delaney (1994).

Current models assume an integral relationship between the main channel of the river and its floodplain and accept the flood pulse and morphological diversity arising from it as the major driving factor in such ecosystems. A series of ancillary considerations such as connectivity are accepted as expressions of river integrity.

It is generally appreciated that rivers and their fauna are very resilient and that measures to improve or rehabilitate them can produce rapid positive responses within the system. In general, rehabilitation should be guided by the principle that if you provide the right conditions of structure and hydrology nature will take care of the rest.

Current theories on floodplain function predict that the area needed for an improvement to the biota is probably relatively small and could lead toward restoration in the form of a string of beads with a series of floodplain patches connected by more restricted river corridors. A primary research role of the Environmental Management Technical Center, in fact, is to help define these floodplain connections.

Existing acquisition programs on the floodplain of the Lower Missouri River include: (1) creation of the new Big Muddy National Fish and Wildlife Refuge, encompassing about 6,000 acres in Missouri; (2) the Partnership for Missouri Wetlands, involving about 32,000 acres (fee or easement) across 25 counties in Missouri by a variety of Federal and State agencies, non-governmental organizations, and private landowners; (3) the Missouri River Fish and Wildlife Mitigation Project, administered by the Kansas City and Omaha Districts of the Corps, which has targeted the acquisition of 14,600 acres in Missouri, 950 acres in Kansas, 7,200 acres in Iowa, and 7,150 acres in Nebraska (SAST, 1994:131); and (4) the Wetland Reserve Program (discussed under measures A and D above, under measure B below, and in Appendix B).

Because of the limited amount of public land on the Missouri River compared to the Mississippi River, it was assumed that a Missouri River EMP would require a larger land acquisition budget. Habitat projects would be defined by the participating States and the U.S. Fish and Wildlife Service and would most likely be prioritized according to goals identified in anticipated ecosystem management planning. Land acquisition for the Missouri River EMP would likely be a primary tool for aquatic habitat restoration on the Missouri River. Assuming a budget of $10 million for land acquisition, a 10-year program, and cost sharing and cost assumptions as in Measure E above, up to 250,000 acres of land could potentially be acquired. This could result in approximately 94,000 acres of forested wetland, and 31,000 acres of non-forested wetlands restored or preserved, with the remaining 125,000 acres as non-wetland.

<u>Cultural Resources Assessment</u>

<u>Scenario 1</u> - Under existing wetland protection and restoration policies, cultural resource impacts are generally taken into consideration since Federal involvement (permitting, funding, etc.) is a critical part of these undertakings.

Overall, the effect on structures and archaeological sites is judged to be slightly negative ($^{-5}$.....$_{-1}$ ^{0}.....$^{+5}$) *simply because mitigation is generally* chosen in favor of cultural resource preservation.

<u>Scenario 2</u> - Cultural resource impacts from increased funding of wetland restoration, improvement, land acquisition, and other assistance would have generally neutral impacts to historic structures which are probably few and far between in the lands proposed for these measures. Archaeological sites could both benefit and suffer from these measures. Positive archaeological impacts derive from abandonment of agricultural activity, while negative impacts would

occur with land modification activities associated with restoration and improvement.

Overall, the effect on structures is judged to be neutral ($^{-5}$.....**0**.....$^{+5}$) while the effect on archaeological sites is judged to be somewhat negative ($^{-5}$...$_{-2}$.^{0}.....$^{+5}$).

<u>Summary</u>: The differences in the three scenarios show how simple changes in targets for a given program can have major impacts on wetlands and other land use in the floodplain. For example, a reduction in CRP acres described in Scenario 1 would likely negate any increased protection offered by the other two programs. Obviously, there are many ways to meet goals of various agencies and organizations, but if programs are made to recognize common goals, greater benefits would ultimately be seen. An increase of 10 to 25 percent in wetland acres restored or protected would have large benefits for the floodplain-river environment, but this would represent only an 8 percent decrease in total floodplain agricultural lands. Targeting marginal lands throughout the system in this way might help minimize impacts on the local tax base, while beginning to establish natural (not protected behind levees) floodplain patches that are needed to improve the biota of the system. It should be noted that, of these major programs analyzed, the EWRP is the only strictly "floodplain" program. However, impacts in the upland watershed, though not estimated in this assessment, could have wide-reaching effects on the floodplain/river system due to water quality and water retention effects over the life of the program.

<u>Agricultural Support Policies Related to Floodplain Use</u>

An initial and obvious question to ask, when looking at floodplain policies and program measures, is whether law, regulation, and economics are working together or are at odds with one another to achieve desired results. Laws and regulations are more difficult to write and to enforce if they are in conflict with perceived economic incentives and disincentives. To provide economic incentives that are not in accordance with stated goals is to guarantee incomplete success. The questions we wished to address, then, were whether agricultural subsidies encourage farming in the floodplain and, if so, is this necessarily undesirable.

Although the numbers vary greatly from farm to farm, it is not unreasonable to assume a needed return of $100 per acre land rent and normal profit. According to analysis done by USDA personnel, an average subsidy amounts to $25 to $85 per acre on floodplain farmland in the study area. Obviously, the subsidy is important. It is estimated that producers will farm as close to a river as the 2-year floodplain.

It was not possible in this assessment to determine what level of risk the farmer would be willing to bear if not subsidized but it is obviously less than if subsidized. However, the incremental costs of planting higher risk acres is so small compared to the possible returns from a good harvest that the individual farmer, accustomed to the risks involved in agriculture, is likely to decide to plant where it may not be indicated on an annualized benefit basis. Agricultural subsidies such as deficiency payments, disaster payments, and subsidized crop insurance clearly reduce or eliminate risk. The conclusion then is obvious: that such policies encourage farming in the floodplain.

The subsidy may or may not be a good investment for the Nation. Benefits include lower consumer prices and increased exports, yet some costs, such as those to the riverine ecosystem, may not be adequately addressed. If subsidies go inefficiently to cover repetitive losses, money may also be wasted. In addition, fairness must be a principle in government policy. Much more disaster assistance goes to agriculture for other reasons, particularly drought, than for flooding. Additional causes include hurricanes, tornadoes, wind, hail, and early frost.

Calculating Agricultural Loss

An additional important question to ask, when looking at floodplain policy and program measures, is what are their true effects on the farm economy. The questions are to what extent losses to regional farmers are offset by gains to other farmers and to what extent government disaster assistance is offset by savings in deficiency payments and loan supports.

There were reductions in both deficiency payments and in commodities being put under loan in 1993. Deficiency payments for Illinois, Kansas, Missouri, South Dakota, and Wisconsin were about $1.5 billion in 1991 and 1992 but dropped by more than $200 million in 1993. Agricultural commodities put under loan totaled 796 million bushels in 1991, 1,200 million bushels in 1992, only 428 million bushels in 1993, and back up to 1,500 million bushels in 1994. There definitely was a decrease in need for these programs and a decrease in government expense associated with these programs.

Aside from those findings, the analysis gets clouded. It was beyond the scope of this assessment to determine how much of the lack of participation in these programs was driven by high prices and how much was driven by having fewer farmers, those who were not flood victims, participating in the market in that year. The effects of grain storage, the buying and selling of commodity futures, large international transactions, and government programs and policies make it difficult to correlate supply and demand shocks through price history. It is safe to assume that government disaster payments were offset to some degree by smaller expenses than normal in these other programs and it is reasonable to say that farmers not affected by severe weather had gains that partly offset losses to stricken farmers (from a national perspective), but these effects should not be overstated. It is not possible in this assessment to determine to what extent these totals were offsetting.

Agricultural Support Policies Within the Three Defined Scenarios

In examining the impact of agricultural support policies on use of the floodplain, the three scenarios discussed in Chapter 5 included the following policy/program elements: Scenario 1 includes Federal crop insurance reform and staying the present course in acreage reserve programs; Scenario 2 considers levee repair criteria, conservation and voluntary acquisition programs, and expanded buyout options; and Scenario 3 considers agricultural premium rates and upland water retention.

Scenario 1 Measures

Existing policies and programs are expected to be maintained, but with known changes implemented since the 1993 flood. Elements included as part of this scenario are Federal crop insurance reform requiring participation by all producers taking part in any other Federal farm program and acreage reserve incentive programs continuing the way they are headed. It is very difficult to predict the final outcome of the various measures currently under consideration. Even where policy has been changed, the details of implementation are often yet to be worked out.

A. Federal Crop Insurance Reform

The Federal Crop Insurance Reform Act of 1994 (Title I, Public Law 103-354) modified the crop insurance program. The goal of the act is to provide an actuarially sound crop insurance program, and to mandate coverage for all producers receiving other farm program benefits.

The methods for implementing several important features of the reform act are still being developed. In general, however, coverage is provided at various levels of risk protection. All producers must obtain at least the base level of catastrophic protection in order to receive other benefits. Producers can also obtain additional levels of coverage at various yield and market price levels.

The fees vary according to the coverage level. The participating producer pays a $50 fee per crop per county up to $200 per county with an overall maximum of $600. For higher levels of additional protection, the fee is $10.

The Federal Government pays the entire cost of the catastrophic level of protection (insuring 60 percent of market prices for losses exceeding 50 percent of individual yields), and a portion of the premium for the additional levels of coverage available from private firms. The premiums are to be sufficient to cover anticipated payouts, a reserve, and administrative and operating expenses.

Implementation procedures for several key elements of the program are still being developed. A most important element is the manner in which "unrated" lands will be addressed. Unrated lands, for purposes of this report, include high risk properties such as those between the rivers and the levees. At the present time, it has not been determined whether these properties will be insured under the standard procedures of the act, whether they will be insured individually with a different rate structure, or whether they will be treated as they would have been under the previous disaster payment systems.

Many facets of the new act are still unclear, but some observations are worth noting:

- There is a benefit in that the cost of disaster from flooding of agriculture would be prepaid. This is easier for the Nation to budget and eliminates unanticipated shocks to the national economy.

- Many farmers who do not now carry crop insurance will have at least a base coverage that is independent of disaster declarations.

- Because the premiums are so heavily subsidized and because participation will be so broad, it is unclear if the Federal Government will spend more or realize savings.

- The base premium is fully subsidized and the base fee is independent of number of acres covered.

- The base premium is fully subsidized and the base fee is independent of risk or loss history. This favors the floodplain farmer whose risk is higher, over the upland farmers whose unit costs of production are usually considerably greater.

B. Acreage Reserve Programs

Land reserve programs such as the Wetlands Reserve Program (WRP), Emergency Wetland Reserve Program (EWRP), and the Conservation Reserve Program (CRP), are assumed to continue based on existing authorization language. The present acreage estimates for each program are listed by State in the Evaluation appendix (Appendix B) and have been discussed under the Floodplain Wetland Restoration Program issue area in the previous section of this chapter. The CRP program is by far the largest at an estimated 212,000 acres in the study area floodplain. The other two programs are on the order of 30,000 to 50,000 acres each for the eight-State study area. The study area lands in these programs, however, represent a very small proportion of total flood prone lands in the area. While they take cropland out of production, thereby reducing flood damages, the programs are not sufficiently large to appreciably reduce flood damages. Yet, as discussed in Chapter 3 and under the Floodplain Wetland Restoration Program issue area in this chapter, there are many other values of wetland and habitat restoration programs beyond the possible flood damage reduction benefits.

The programs have been very popular. Since its inception, the WRP has received substantially more applications nationwide than it has been able to support. In Fiscal Year 1991, with a total budget of $46.7 million, 249,000 acres were offered for enrollment, while only 50,000 were accepted. The program was not funded in Fiscal Year 1992. In Fiscal Year 1993, with a budget of $66.7 million, approximately 600,000 acres were offered for enrollment, while only 75,000 acres were accepted.

To estimate the number of acres of wetland that would be restored or protected under this measure, the same assumptions were made for WRP and EWRP as described under Measure A of the Floodplain Wetland Restoration Programs section above. The CRP would change, and estimates for this program are described below.

Conservation Reserve Program - As previously described, it was assumed that at the time of the flood, 212,000 acres were enrolled. It was further assumed under this scenario measure that this acreage is reduced by 50 percent as currently proposed. Such a change would result in the loss of 106,000 acres of natural cover currently protected under this program. Assuming that 10 percent of these CRP lands are wetland, a loss of 10,600 (see matrix table 1) would result. Costs were estimated by using the current average cost of $54 per acre for 10 years. There would be reduced costs under this scenario of $57 million.

Other Programs - As discussed above for Floodplain Wetland Restoration measures, it was assumed that these additional programs would contribute 10 percent of the three major ones (EWRP, WRP, CRP). This would amount to approximately 13,000 acres. Costs were estimated assuming $1,500 per acre for agricultural conversion resulting in ~$20 million.

It is impossible to tell what will be done to these programs in the 1995 Farm Bill, but indications are the budget for reserve programs will be cut to some degree. It would require a considerable increase in expenditures for these programs to have significant impacts on flood damages in the study area. These programs enjoy a good reputation for environmental benefits and, especially in the case of the wetlands programs, take excessively risky land out of crop production. For this reason, these programs will act to decrease crop damage and agricultural subsidies in a very marginal way. Program opportunities in upland retention are covered under measure G below and in Chapter 8.

Scenario 2 Measures

The philosophy of this scenario assumes a more proactive position toward program and policy reform to reduce risk, use resources efficiently, and enhance the environment. Elements examined are similar to many proposals found in reports by the Interagency Floodplain Management Review Committee, the Mississippi River Basin Association, and the Association of State Floodplain Managers. Specific agricultural elements examined as part of this scenario include levee repair criteria which considers repetitive breaks, maintenance history, and environmental and social effects compared with alternative approaches. Another element assumes the 1995 Farm Bill would continue conservation and voluntary acquisition of marginal farmland, emphasizing environmental restoration and enhancement. The third element includes explicit consideration of environmental attributes to expand opportunities for buyout options.

C. Levee Repair Criteria

The present system of agricultural flood-control levees along the lower Missouri River and upper Mississippi River floodplain is an aggregate of levees constructed by different agencies and individuals at various times and under various programs. Their physical composition, degree of flood protection, and locations vary from area to area. Some are on or near the channel bank and extend across old river channel deposits. Others are set back to the landward margin of the floodway to permit flood flow conveyance.

Private levee systems such as those built along the Missouri River, riverward of the Federal levee system, were often placed as close to the river as possible. Many of these private levees have tie-offs into existing Federal levees, and do not allow for the recommended floodway. Any secondary levee riverward of the Federal levee system on the lower Missouri River is not only within the 3,000-foot-wide floodway defined in 1962, but is also within the floodway defined at present by the National Flood Insurance Program.

If damaged during a flood, such a levee may not meet the specific criteria for repair under one Federal program, but may qualify for assistance under another program due to the inconsistent Federal levee repair policy from agency to agency. Levees are repaired without mitigating the adverse effects these levees may have on the NFIP floodway and also on the capacity of adjacent "mainline" levees. Regulation of the floodway is the responsibility of the local municipality. In the area of regulation, a lack of coordinated planning and management undermines the Federal and State objective of sound floodplain management.

Levees that do have a history of repetitive damage could be evaluated for factors contributing to the levee damage and solutions found to lessen or eliminate the damage caused. If repetitive losses and adverse effects on floodwater surface elevations are properly analyzed, many levees may not be justified for repair.

Another area to consider is whether adequate maintenance is being performed. Drainage districts contacted in Missouri, for an example, with levee lengths of 10 to 30 miles, reported a range of average annual maintenance costs from $300 to $3,500 per mile of levee. The Papio-Missouri River Natural Resources District (NRD) in Nebraska reports an average annual maintenance cost of $3,500 per mile of levee. A levee with a $300 per mile maintenance cost is probably not being maintained adequately.

Damaged levee systems are generally not investigated with any hydrologic models before repair. Studies indicate that some private levees are detrimental to flood protection provided by Federal levees and contribute to erosion damage, higher stages, and increased sediment deposition. Repair of private levees was often promoted by Federal agencies even though these same levees often compromise the effectiveness of the Federal levee system. In public meetings held by Omaha District, there have been indications of local support for limiting or eliminating the private levees riverward of the Federal levees.

Location of repetitive breaks in particular levee units must be examined with respect to placement in relation to former channel alignments. As pointed out earlier, the problem may be in where the levee was placed in relation to former channel alignments. Problems may also relate to the levee having other than the design level of protection due to aggradation or change in conveyance or hydrology.

A detailed environmental analysis of the effects of levee rehabilitation involving 303 levee setbacks or realignments is provided in Appendix B. Such rehabilitation could lead to less repetitive levee damage. Detailed studies would be required, however, to develop optimal alignments and new designs that would allow predictable and controlled flooding behind levees to minimize the widespread erosional and depositional damage seen in the 1993 flood. The major effects this analysis of levee realignments identified on FPMA environmental impact categories included restoration of 5,600 acres of non-forest wetland and 2,000 acres of forest. The cost of this action was estimated to be $57 million.

D. Conservation and Voluntary Acquisition Programs

This measure states that the 1995 Farm Bill will continue conservation and voluntary acquisition program emphasizing restoration of marginal agricultural areas frequently flooded to wetlands and natural habitat. The direction that Congress sets in the Farm Bill is integral to the future course of this area of study because the Farm Bill and associated incentives for production or set-aside can have a major effect on land use. Although the actual status of the 1995 Farm Bill is uncertain at the time of this analysis, we have analyzed the measure as stated above.

Conservation Reserve Program - Although it was estimated that 212,000 acres in the FPMA study area floodplain are currently enrolled in the CRP, this Scenario 2 measure emphasizes restoration of frequently flooded marginal agricultural lands. It was assumed that of the 5.3 million acres of flood prone cropland in the FPMA counties, 25 percent or 1.3 million acres are in the FPMA floodplain. Of this 1.3 million flood prone acres in the study area, 10 percent or 131,000 acres will be targeted as convertible to wetland. Based on existing ratios of land cover, it is assumed that 100,000 acres will revert to floodplain forest and 31,000 will revert to non-forested wetland. The cost for this program for the FPMA study floodplain will be similar to the existing CRP, assuming a 10-year program at $54 per acre per year. Total cost would be approximately $71 million.

Wetland Reserve Program - Of the program goal of 1 million acres, 22 percent (based on existing sign-up) are assumed to be in the FPMA States. Because frequently flooded, marginal agricultural lands are "targeted" under this Scenario 2 policy measure, we increased the estimated percentage of enrolled WRP acres in the floodplain to 75 percent. This leads to approximately 157,000 additional acres restored if the program meets it goals. The cost would be ~$142 million based on current program expenditures.

Restoring the integrity of the environment is important for maintaining a high quality of life, but it is difficult to evaluate many environmental benefits in monetary terms. Obviously, land acquisition and environmental restoration and enhancement bear monetary cost, but costs of a degraded environment can also be measured in decreased productivity of natural systems (loss of species, contaminated fish stocks, declines in shellfish, etc.), which in turn ultimately affect the health of humans.

While the impact of these programs on flood damage reduction may be small for infrequent flood events (see Chapter 8), the range of benefits generated by these programs has been estimated to be very large (Ribaudo et al., 1990). This is especially true if upland effects of the programs are also considered. Unfortunately, a detailed cost and benefit analysis for these and other environmental initiatives was beyond the scope of this assessment. It would be most valuable to assess effects of these programs over a wide range (frequency) of flood events and to have the capability to link the biological response with the hydrologic and hydraulic model outputs to truly integrate the analysis.

E. Expanded Buyout Options

To consider buyout options with added weight given to environmental considerations would expand the opportunities for buyouts. Buyout options are to be considered rather than easements when a permanent solution is preferable and the opportunity arises. Two constraints on expanding the use of buyouts are the initial cost and the owner's willingness to sell. The costs are a matter of economics and must be looked at on a case-by-case basis, although considerable preliminary analysis beforehand would allow for optimizing the pursuit of worthwhile opportunities. Assuming that it is worthwhile that some buyouts be pursued, the interesting question is what makes the landowner a willing seller. The landowner has personal and economic ties to his or her property.

1) Personal Considerations

To many farmers, their land is a part of their heritage and their way of life. They have considerable personal investment in area schools, churches, politics, businesses, and social relationships. Often, many members of their families live nearby. To uproot them may cause considerable duress. This impact may be even greater if there is insufficient availability of nearby land to farm. The degree to which a farmer feels he is being adequately compensated will strongly influence his willingness to sell. If forced to begin a new occupation in a new community, the farmer's unwillingness to sell may be difficult to compensate.

2) Economic Considerations

The economic costs would include the financial cost of the upland farm site, the cost of acquiring equipment more suited to upland farming, and the cost of the move, to name three obvious examples. In the Missouri River basin, the labor required to farm an upland acre of rolling to moderately steep hills can be approximately 33 percent greater than to farm floodplain land. Some reasons for this additional labor are the contour plowing required on the upland hills, more frequent turning of equipment, and slower speeds to ensure that the large equipment remains upright.

Based on Iowa data, returns to management for floodplain farmland with a minor degree of flooding appear to be greater than returns to management for upland farmland. Over a 10-year period, the calculated per-acre returns to management for uplands that never flood were less than for floodplain land where soggy field conditions force late-planting of soybeans (giving a yield 78 percent of normal) 2 years out of 10 and were only slightly greater than for floodplain land on which the first crop was flooded out, forcing a late replanting of soybeans with 78 percent of normal yield, 1 year out of 10.

A farmer who owns his land, paying only the tax levy, can financially withstand much more in flood damages which are not reimbursed by insurance than can a farmer who is making rent or mortgage payments on the land. The cash rent equivalent in the Iowa crop budgets ranged from 32 to 39 percent of the calculated gross receipts per acre. It was estimated that net returns per acre for a floodplain farmer who does not own his own land could become negative over a 10-year period if floods caused a complete crop loss 1 year out of 10 and flooded his first crop, forcing a late planting of soybeans at reduced yield, 1 year out of 10. The estimated net returns per acre for a floodplain farmer who owns his own land could become negative over a 10-year period if floods caused a complete crop loss 3 years out of 10 and his first crop flooded, forcing a replanting at reduced yield, several more years out of 10. Of course, even though farmers owning their own land are better able to weather adversity, they still expect to earn a normal profit over time.

3) Local Impacts

The other factor that has to be taken into account in buyouts is the loss to the community and the local tax base that occurs. These agricultural areas are generally lacking in population and infrastructure to provide a good tax base and to support local commercial establishments. The effect on local communities, businesses, and taxing authorities must be considered in any successful buyout program.

<u>Scenario 3</u>

Scenario 3 emphasizes avoiding exposure to flooding by avoiding development in the floodplain and encourages restoration of environmental resources. The first of the two agricultural policy elements for this scenario is that crop insurance premium rates would reflect the actuarial risk for farming in the floodplain area. The second element is expanded use of upland runoff detention using tools such as terracing, no-till farming, and windbreaks to reduce peak runoff and sedimentation.

F. Actuarially Based Crop Insurance Premium Rates

It is assumed that actuarially based means the whole premium is paid by the investor in a business enterprise with uncertain returns and that the premium is commensurate with that risk and sufficient over time to meet all demands. This would produce some tremendous benefits. It would somewhat discourage farming of marginal lands. More importantly, it would save the taxpayers a large amount of money by eliminating the transfer payment from the taxpayers to those whose investment risk is partially subsidized. It would avoid the unanticipated shocks to the budget and to the economy. And, it would allow market mechanisms to allocate agricultural resources in a more efficient manner. Conversely, it would also raise the cost of production for some farmers and possibly cause some rise in consumer prices.

Another problem is that completely actuarially based crop insurance is not feasible in the purest sense of the definition. To base the premium entirely on actual risk requires that the risk for each parcel of land be accurately assessed. This is an impossible task in other than a somewhat generalized way. To track and update risk history is also a challenge administratively.

Furthermore, without some subsidy of premium, there may be little incentive for participation. When a disaster strikes, based on history, it is probable that disaster payouts would be made available to the uninsured.

The answer reasonably lies somewhere short of the extreme. By being more actuarially based, the benefits mentioned would be realized to an increased degree. There would be an increased need for risk assessment and the maintenance of ongoing loss history records. There would also reasonably be an ongoing need for some limited subsidy unless some other effective compliance mechanism could be found.

G. Upland Water Retention

The Scientific Assessment and Strategy Team (SAST), in preparing its efforts for the Galloway report, conducted an assessment of the effects that upland management practices would have on flood flows. The results of this assessment are presented in Chapter 7, Section IV: The Engineered System of the SAST report (1994). The SAST examined four watersheds in the study area and, in three of the basins, modeled the potential effects of various land management practices. In the fourth watershed, the SAST examined the effects a significant increase in wetlands development would have on runoff.

For each alternative, total coverage of the basin was assumed, thus estimating the maximum effect of the alternatives on flood flows. The analysis examined the effects of these alternatives at various flood levels. The results varied from basin to basin, ranging from slightly less than 1 percent to nearly 40 percent. The combination of all alternatives showed very significant reductions in peak flows for three of the four basins. The high variation among the basins points to the need for basin specific analyses. FPMA results of further hydrologic modeling for the 1993 flood event are presented in Chapter 8.

A summary of current land treatment by State was generated by NRCS staff from their Natural Resources Inventory database (see Appendix B). This information includes total cropland acres, acres exceeding T (tolerable soil loss), acres of highly erodible soil, and for some States, acres treated with specific conservation practices. These data can be used as a starting point to assess the upland acres potentially treatable in each State by various programs and practices, and thereby assess what a reasonable amount of runoff reduction might be in various parts of the basin. We were unable to complete such an assessment for the FPMA.

Numerous studies indicate that upland farm management practices that reduce runoff have very beneficial effects in reducing soil erosion and sedimentation, in improving water quality, and in enhancing fish and wildlife habitat. There are also flood control benefits, primarily on a more local level with the more frequent levels of flooding. For the 1993 flood, on the large tributaries and main stem Missouri and

Mississippi Rivers, these practices would not have made a large difference. In the alternatives analysis discussed in Chapters 8 and 9, there is further discussion of upland water retention measures.

Scenario 1 Effect on Impact Categories

A very small drop in some damage and government expenditure categories, mostly related to agriculture, is possible if the Federal Crop Insurance Reform Act is implemented in such a way that incentives to farm marginal land are reduced. The effect would be minimal, involving only the relatively few acres within this marginal category. The only two impact categories that will surely see major change are Federal Crop Insurance Corporation flood insurance payouts and disaster assistance to agriculture. Presumably, what once was paid in disaster payouts might now go to the insurance system. Wetland acreage would increase by roughly 14 percent (127,000 acres).

Scenario 2 Effect on Impact Categories

The emphasis given to environmental considerations in levee repair criteria and to the restoration of marginal agricultural lands would be beneficial to most of the environmental impact categories. Increases in wetland acreage would increase significantly (32 percent) under these measures. Agricultural damage and assistance categories would be decreased by a small amount. Of course, anything that removes people or structures from the floodplain reduces risk. Programs designed to move people and/or economic pursuits from the floodplain must consider all the social, economic, environmental, and safety issues on a personal, local, regional, and national level to be both worthwhile and effectively implementable.

The approach directed by Scenario 2 has benefits and costs that vary from one area to another. If the present levee inventory was more complete, including the continuing updating of levee history and Geographic Information System (GIS) accessibility of levee alignments and historical river configurations, including private levees, a site-by-site analysis would be facilitated. Local sponsor levee maintenance and repair need to be an integral part of an overall systemic plan.

Scenario 3 Effect on Impact Categories

The two agricultural elements of Scenario 3 would act to reduce the incentive of subsidized risk in farming in the floodplain and reduce the size of any particular floodplain by reducing upland runoff. A more actuarially based insurance system would decrease agricultural damages slightly and would eliminate agriculturally related disaster payments.

The decrease in peak runoff (for the 1993 event) would slightly decrease damages and disaster assistance, in general, but the primary gain would be to local watershed areas in reduced flooding from frequent events and providing environmental benefits.

Summary: There is lots of uncertainty over possible changes in floodplain resources and impacts resulting from reforms in agricultural support policies and programs. From the perspective of the FPMA evaluation framework, the crop Insurance Reform Act of 1994 should represent a significant shift from agricultural disaster assistance to crop insurance protection, though it is not clear that a large reduction in Federal Government expenditures will result because of the provisions that subsidize the purchase of crop insurance. Restoration and conservation programs have the potential to contribute to enhanced natural resource values and to reduce exposure to flood damages, but their limited size (the Conservation Reserve Program excepted) makes it unlikely that large-scale floodplain land use conversions in rural areas will take place. They might prove significant, however, in conversion of marginal lands that would then begin to reestablish the natural floodplain patches necessary to improve the integrity of the river ecosystem. A more rigorous review of levee repair criteria would help to ensure that funding for repairs is most efficiently applied.

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Findings

Statements reflecting the outcome of research and analysis completed in the review of policy and program measures covered in this chapter are provided below. Additional information and data on some of these points are found in Appendix B (Evaluation) to this report.

NATIONAL FLOOD INSURANCE

7-a) The definition of "floodplain location," using the 100-year flood outline, may not be adequate. Twenty-four percent of all losses covered by the National Flood Insurance Program for the period 1978-1993 were for damages outside (above) the 100-year floodplain. Some of these problem areas are related to high groundwater from heavy rainfall or poor interior drainage not directly related to a general condition of overbank flooding.

7-b) Compliance with prior flood insurance requirements has not always been adequate to ensure purchase of needed insurance. NFIP reform legislation in 1994 now requires lending institutions to ensure that flood insurance for mortgages on structures within the 100-year floodplain is obtained and maintained.

7-c) The Community Rating System (CRS) under the National Flood Insurance Program has potential to decrease the national exposure to flood risk by improving floodplain management and flood damage avoidance capabilities at the local level. The CRS is a program of the Federal Insurance Administration to award reductions in flood insurance premiums based on the effectiveness of a community's flood preparedness, damage reduction measures, mapping and regulations, and public information about flood hazards.

STATE AND LOCAL FLOODPLAIN MANAGEMENT AND ZONING REGULATIONS

7-d) State and local floodplain zoning and regulation could be most effective in addressing critical facilities that have the potential for toxic or hazardous releases by imposing stricter requirements for the siting of these facilities.

7-e) Improved floodplain management, including land use planning, zoning, and enforcement at the local and State level, can reduce flood related damages. There are still communities and municipalities without zoning ordinances to reduce flood risks or plans to mitigate flood related damages.

RELOCATION, MITIGATION, AND DISASTER RELIEF

7-f) Flood hazard mitigation options, particularly acquisitions (buyouts) of substantially damaged residential structures, have been a more prominent part of the Federal response in recovering from the 1993 Midwest flood. The process is underway for more than 8,000 parcels in the 1993 flood area (most are residential structures) to be acquired as part of the strategy to avoid repetitive flood damage in vulnerable floodplain locations. Close to $200 million, largely in FEMA Section 404 Hazard Mitigation Grant funds and HUD Community Development Block Grant funds, has been made available to pursue hazard mitigation projects in the 1993 flood area, with by far the largest share directed toward acquisition of damaged properties.

7-g) The Hazard Mitigation and Relocation Assistance Act was signed into law on December 3, 1993. It increased from 10 percent to 15 percent the share of total Federal disaster assistance that can be devoted to property acquisition and relocation projects, and increased the Federal cost share on eligible hazard mitigation and relocation projects from 50 percent to 75 percent. The additional funds and larger Federal cost share in paying for the projects has significantly increased interest by the local governments and communities affected.

7-h) The National Flood Insurance Reform legislation, Title V of the Riegle Community Development and Regulatory Improvement Act, was signed into law on September 23, 1994. Section 1367 establishes a new National Flood Mitigation Fund, with funding increasing to $20 million annually in Fiscal Year 1996 and beyond, financed from NFIP premiums, to pursue future flood mitigation projects. Section 1366 provides up to $1.5 million annually from the National Flood Mitigation fund for mitigation planning assistance to States and communities.

7-i) Future Federal expenditures could be reduced by not providing disaster assistance for structures on Federally leased land (cottage leases along the Mississippi River). This could be implemented as a condition of lease renewal.

7-j) Future disaster assistance and insurance needs could be significantly reduced if the problem of repetitively damaged structures is firmly addressed through implementation of existing regulations by local, State, and Federal agencies.

7-k) More extensive reliance on flood insurance would better assure that those who invest, build, and live in the floodplain accept appropriate responsibility for the damages and other losses that result from floods.

7-l) More emphasis is now being placed on use of flood hazard mitigation measures, especially acquisitions of flood-prone structures, as an action that will reduce repeated Federal disaster expenditures and other costs associated with areas of widespread and potentially substantial repetitive flooding.

FLOODPLAIN RESTORATION

7-m) The difference between "natural floodplain restoration" and "wetland restoration" is an important distinction to make. Restoration of the natural floodplain requires changes in the levee system to restore natural hydrologic functions and create the linkage back to main channel areas.

7-n) Conversion of agricultural floodplain lands to wetlands and natural floodplain would have reduced payments for agricultural damages.

7-o) A stream restoration program that could enhance over 1,000 miles of tributary rivers and streams in each State in the FPMA study area would require a budget similar to the Wetland Reserve Program.

7-p) Wetland restoration programs are typically underfunded relative to the interest in participating in those programs.

7-q) A broader program to minimize the impact of local government's lost tax revenues resulting from land conversions would be beneficial and could reduce some of the opposition to these programs.

7-r) Conversion or restoration of a small percentage of agricultural land use to wetland or other natural conditions can significantly increase the existing percentage of natural floodplain acreage.

7-s) Current theories on floodplain function predict that the area needed for an improvement to the natural biota is probably fairly small and that restoration of a series of natural floodplain patches (a string of beads) connected by more restricted river corridors would be practical and beneficial.

7-t) Converting floodplain agricultural land to natural floodplain vegetation would not reduce stages but would marginally reduce damage payments in the 1993 Midwest flood. Agricultural use of the floodplain is appropriate when the residual damage of flooding is understood and accepted within a financially sound program of crop insurance and flood damage reduction measures and when it is compatible with the risk to natural floodplain functions.

AGRICULTURAL SUPPORT POLICIES AND CROP INSURANCE

7-u) The Federal Crop Insurance Reform Act of 1994 has replaced disaster assistance for agricultural crops with a prepaid insurance system for all farmers participating in other Federal farm programs.

7-v) The "Farm Bill" and associated incentives for production or set-aside can have a major effect on floodplain land use and, thereby, a major influence on the environmental quality of the floodplain-river system.

7-w) Use of acreage reserve, acquisition, and environmental restoration programs is an effective way to remove vulnerable agricultural production from marginal lands and to generate many environmental benefits.

7-x) Acreage reserve programs in upland areas have significant environmental benefits in the areas such as water quality, reduced sedimentation, increased wildlife habitat, and reduced peak runoff for local flood reduction benefit for frequent events, but do little to reduce stages on the main stem rivers for catastrophic events.

7-y) Levee repair criteria are not sufficiently based on repetitive break history, maintenance history, environmental considerations, hydrologic analysis, economic analysis, or system-wide effect.

7-z) Although much progress has been made, in this assessment and before, toward completing a GIS-based levee inventory, more needed work remains, especially concerning private levees, historic river configurations and hydrologic history, cultural resources, and environmental and economic land use.

7-aa) There is sufficient reason and support for State and Federal agencies to examine the justification for private levees that encroach the floodplain and diminish the integrity of Federal levees.

7-bb) There is ample evidence that a major problem with existing levees is that, in many cases, inadequate resources are being devoted to routine maintenance, causing decreased levels of protection and increased interior ponding behind levees.

7-cc) Acquisition of marginal farmland and environmental restoration of that land should be evaluated on both a site-by-site and system-wide basis. This will help to ensure that the acquisitions are consistent with systemic management goals and ensure that limited funds are spent most efficiently.

7-dd) The purchase of agricultural or developmental interests through buyout programs must take into account the needs of the seller and the local community, business community, and all taxing authorities to be well received and successful.

Table 7-3

SCENARIO CATEGORIES (FLOODPLAIN SCENARIO 1)

	IMPACT CATEGORIES	A Base Cond. [All Disast. Counties]	B Base Cond. [FPMA Imp. Counties]	C National Flood Ins. Program Regs.	D State Fldpln. Mgmt & Zoning	E Local Fldpln. Mgt & Zoning	F Relocation, Mitigation Programs	G Disaster Relief Programs	H Floodplain Wetland Restor.Proc	I Agricultural Support Policies	J Signif. Findings
	ECONOMIC (1,000 $'s)		[1]								
	Flood Damages										
1	Residential (Urban)	$760,892	$662,008	LOW	– LOW	– LOW	–200,000	–< 5%	0	0	
2	Other (Urban)	$1,612,543	$1,447,322	LOW	– LOW	– LOW	–15,000	–< 5%	0	0	
3	Agricultural	$3,852,701	$817,054	0	0	0	0	0	0	(–) SMALL	
4	Other Rural	$233,648	$161,010	LOW	– LOW	– LOW	0	0	0	NEGLIG.	
	Chg. in Govt.Expend.										
5	Emergen.Resp.Costs	$227,405	$200,663	LOW	– LOW	– LOW	–20%	–< 5%	0	(–) NEGL.	
6	Disaster Relief (Agric.)	$1,160,632	$285,180	0	0	0	0	0	0	0	
7	Disaster Relief (Human R.)	$1,297,474	$551,862	+82,000	– LOW	– LOW	–100,000	–< 5%	0	(–) NEGL.	
8	Flood Insurance (NFIP)	$371,969	$276,496	–82,000	– LOW	– LOW	–10%	–< 5%	0	(–) NEGL.	
9	Flood Insurance (FCIC)	$748,095	$269,061	0	0	0	0	0	0	$64,484	
	Chg.Value of FP Resources										
10	Net Ag RE Values	–	–	0	0	0	0	0	0		
11	Net Urban RE Values	–	–	0	0	0	< 5%	0	0		
	ENVIRONMENTAL										
	Natur.Resour.(# acres)										
12	Non–Forested Wetl. (acres)	–	365,285	0	0	0	0	0	37,000	32,000	
13	Threat.&Endang. (# / Occ.)	–	(281/1,043)	0	0	0			+	0	
14	Forest (acres)	–	534,705	0	0	0			110,000	95,000	
	Natural Fldpln.Functions										
15	Fldpln.Inundated (acres)	–	2,685,281	0	0	0			0		
	Cultural										
16	Archeol Impacts (–5 to +5)	–	–1	–1(+1)	0(0)	0(0)	–1(0)	–1(0)	–1(NA)		
16A	Hist.Sites(–5 to +5)		–1	–1(+1)	0(0)	0(0)	–1(0)	–1(0)	–1(NA)		
	Open Space										
17	Public lands (acres)	–	392,512	0	0	0			26,000	13,000	
18	Recreation sites (#)	–	485	0	0	0			25	10	
	REDUCT.OF RISK										
	Critical Facilities										
19	# Facil. w/harmful releases	–	207	0	– LOW	0	–< 5%	0	0		
20	# other critical facilities	–	1,208	0	– LOW	0	–< 10%	0	0		
	Prot./Avoid. of Harm										
21	# people vulnerable	185,630	134,849	LOW	– LOW	– LOW	–20,000	–< 5%	0		
	Social Well Being										
22	# communities vulnerable	433	293	0	– LOW	– LOW	–100	0	0		
23	# resident.struct.vulnerable	56,339	42,743	LOW	– LOW	– LOW	–6,000	–< 5%	0		
	IMPLEMENT. COSTS										
24	Structural Costs	–	–	0	0	0	+$215,000	+< 5%	–	–	
25	Other Costs	–	–	+ MODERATE	+ LOW	+ LOW	+$90,000	0	$190 mil	$108 mil	

File:SCENCAT1

[1] Economic impacts collected only at the county level

Table 7-4

SCENARIO CATEGORIES

(FLOODPLAIN SCENARIO 2)

	IMPACT CATEGORIES	A Base Cond. [All Disast. Counties]	B Base Cond. [FPMA Imp. Counties]	C National Flood Ins. Program Regs.	D State Fldpln. Mgmt. & Zoning	E Local Fldpln. Mgmt. & Zoning	F Relocation, Mitigation Programs	G Disaster Relief Programs	H Floodplain Wetland Restor.Pro	I Agricultural Support Policies	J Signif. Findings
	ECONOMIC (1,000 $'s)		[1]								
	Flood Damages										
1	Residential (Urban)	$760,892	$662,008	LOW	– HIGH	– LOW	– < 5%	–< 5%	0	0	
2	Other (Urban)	$1,612,543	$1,447,322	LOW	– HIGH	– LOW	0	–< 10%	0	0	
3	Agricultural	$3,852,701	$817,054	0	0	0	0	0	<–5%	(–)	
4	Other Rural	$233,648	$161,010	LOW	– LOW	– LOW	0	0	0	(+)	
	Chg. in Govt.Expend.										
5	Emergen.Resp.Costs	$227,405	$200,663	LOW	– HIGH	– LOW	–< 5%	–< 15%	<–5%	(–) NEGL.	
6	Disaster Relief (Agric.)	$1,160,632	$285,180	0	0	0	0	0	<–5%	NA	
7	Disaster Relief (Human R.)	$1,297,474	$551,862	LOW	– HIGH	– LOW	– < 5%	–375,000	0	(–) NEGL.	
8	Flood Insurance (NFIP)	$371,969	$276,496	MODERATE	– HIGH	– LOW	–< 5%	+20%	0	(–) NEGL.	
9	Flood Insurance (FCIC)	$748,095	$269,061	0	0	0	0	0	<–5%	NA	
	Chg.Value of FP Resources										
10	Net Ag RE Values	–	–	0	0	0	0	0	<–5%		
11	Net Urban RE Values	–	–	0	0	0	< 5%	–< 5%	0		
	ENVIRONMENTAL										
	Natur.Resour.(# acres)										
12	Non–Forested Wetl. (acres)	–	365,285	0	0	0	0	0	52,000	77,600	
13	Threat.&Endang. (# / Occ.)	–	(281/1,043)	0	0	0	0	0	+	+	
14	Forest (acres)	–	534,705	0	0	0	0	0	157,000	218,000	
	Natural Fldpln.Functions										
15	Fldpln.inundated (acres)	–	2,685,281	0	0	0	0	0			
	Cultural										
16	Archeol Impacts (–5 to +5)	–	–1	–1(+1)	–1(+1)	0(0)	–1(+1)	–1(+1)	–1(?)	–1(NA)	
16A	Hist.Sites(–5 to +5)	–	–1	–1(–2)	–1(–2)	0(0)	–1(–2)	–1(–2)	–1(?)	–1(NA)	
17	Open Space										
17	Public lands (acres)	–	392,512	0	+	0	0	0	80,000	8,000	
18	Recreation sites (#)	–	485	0	+	0			75	5	
	REDUCT.OF RISK										
	Critical Facilities										
19	# Facl. w/harmful releases	–	207	0	– HIGH	– LOW	0	–< 5%	0		
20	# other critical facilities	–	1,208	0	– MODERATE	– LOW	0	–< 5%	0		
21	Prot./Avoid. of Harm	–									
21	# people vulnerable	185,630	134,849	LOW	– HIGH	– LOW	–< 5%	–< 5%	0		
	Social Well Being										
22	# communities vulnerable	433	293	0	– MODERATE	– LOW	0	–< 10%	0		
23	# resident.struct.vulnerable	56,339	42,743	LOW	– HIGH	– LOW	–< 5%	0	0		
	IMPLEMENT. COSTS										
24	Structural Costs	–	–	0	–	–	+<$10,000	+$50,000	$8 million	$60 million	
25	Other Costs	–	–	LOW	+ HIGH	+ MODERATE	+$600	+$100	$196 mil.	$153 mil.	

File:SCENCAT2

[1] Economic impacts collected only at the county level

Table 7-5

SCENARIO CATEGORIES (FLOODPLAIN SCENARIO 3)

	IMPACT CATEGORIES	A Base Cond. [All Disast. Counties]	B Base Cond. [FPMA Imp. Counties]	C National Flood Ins. Program Regs.	D State Fldpln. Mgmt. & Zoning	E Local Fldpln. Mgt & Zoning	F Relocation, Mitigation Programs	G Disaster Relief Programs	H Floodplain Wetland Restor. Proc	I Agricultural Support Policies	J Signif. Findings
	ECONOMIC (1,000 $'s)		[1]								
	Flood Damages										
1	Residential (Urban)	$760,892	$662,008	LOW	– LOW	0	–< 10%	–< 5%	0	0	
2	Other (Urban)	$1,612,543	$1,447,322	LOW	– LOW	0	–< 10%	–< 5%	0	0	
3	Agricultural	$3,852,701	$817,054	0	0	0	0	0	<–10%	(–)	
4	Other Rural	$233,648	$161,010	LOW	– LOW	0	0	0	0	(–)	
	Chg. In Govt.Expend.										
5	Emergen.Resp.Costs	$227,405	$200,663	LOW	– LOW	– LOW	–< 5%	–< 10%	<–10%	(–) NEGL.	
6	Disaster Relief (Agric.)	$1,160,632	$285,180	LOW	0	0	0	0	<–10%	0	
7	Disaster Relief (Human R.)	$1,297,474	$551,862	LOW	– LOW	0	–< 5%	–25%	0	(–) NEGL.	
8	Flood Insurance (NFIP)	$371,969	$276,496	MODERATE	– LOW	– LOW	–< 5%	+ 100%	0	(–) NEGL.	
9	Flood Insurance (FCIC)	$748,095	$269,061	0	0	0	0	0	<–10%	$64,484	
	Chg.Value of FP Resources										
10	Net Ag RE Values	–	–	0	0	0	0	0	<–10%		
11	Net Urban RE Values	–	–	0	– MODERATE	0	< 5%	–< 5%	0		
	ENVIRONMENTAL										
	Natur.Resour.(# acres)										
12	Non–Forested Wet. (acres)	–	365,285	0	+	0	0	0	31,000	+0	
13	Threat.&Endang. (# / Occ.)	–	(281/1,043)	0	+	0	0	0	+	+	
14	Forest (acres)	–	534,705	0	+	0	0	0	94,000	+0	
	Natural Fldpln.Functions										
15	Fldpln.inundated (acres)	–	2,685,281	0	0		0	0			
	Cultural										
16	Archeol Impacts (–5 to +5)	–	–1	–1(+2)	–1(0)	0(0)	–1(+2)	–1(+2)	–1(?)	–1(NA)	
16A	Hist.Sites(–5 to +5)	–	–1	–1(–3)	+1(0)	0(0)	–1(–2)	–1(–2)	–1(?)	–1(NA)	
	Open Space										
17	Public lands (acres)	–	392,512	0	+	0	+	0	200,000	+0	
18	Recreation sites (#)	–	485	0	+	0	+	0	100	+0	
	REDUCT.OF RISK										
	Critical Facilities										
19	# Facl. w/harmful releases	–	207	0	– LOW	0	0	–< 5%	0		
20	# other critical facilities	–	1,208	0	– LOW	0	0	–< 5%	0		
21	Prot./Avoid. of Harm										
21	# people vulnerable	185,630	134,849	LOW	– LOW	0	< 10%	+ 25%	0		
	Social Well Being										
22	# communities vulnerable	433	293	0	– LOW	0	–20	+> 5%	0		
23	# resident.struct.vulnerable	56,339	42,743	LOW	– LOW	0	–< 10%	+ 25%	0		
	IMPLEMENT. COSTS										
24	Structural Costs	–	–	0	–	–	+$100,000	+$100,000	$50 million	$100,000	
25	Other Costs	–	–	MODERATE	+ LOW	+ LOW	+$25,000	+$500,000	$50 million	$500,000	

File:SCENCAT3

[1] Economic impacts collected only at the county level

CHAPTER 8 - HYDRAULIC MODELING OF "ACTION ALTERNATIVES"

INTRODUCTION

As discussed in Chapter 4, which described the Floodplain Management Assessment (FPMA) evaluation process, the impacts of action alternatives, or those alternatives which would affect the hydrologic and hydraulic conditions in the floodplain, are to be measured against the 1993 flood as a base condition. An initial step was to perform hydraulic routings of these alternatives to determine changes in river stages so that the impacts of such changes could be identified and evaluated. Systemic hydraulic routings, or continuous hydraulic modeling on the entire reaches of the middle and upper Mississippi and lower Missouri River main stems, have been accomplished on some of the alternatives, whereas others have been evaluated on impact study reaches or as individual case studies. Those alternatives that have been evaluated systemically include: (The letter designation relates to the corresponding column in the impact matrix tables in Chapter 9.)

L - Removing all agricultural levees.
M - Setting back agricultural levees.
N - Establishing uniform height 25-year levees.
O - Raising all levees so that the 1993 flood would have been confined.
S - Removing existing reservoirs.
V/W - Reducing upland runoff by 5 and 10 percent.

Other alternatives that have been evaluated but not on a systemic basis included:

K - Limiting floodfighting.
P - Providing 500-year protection for urban areas.
Q/R - Providing 500-year protection for critical facilities (priority sites and all sites).
T - Providing additional reservoirs.
U - Revising operation of reservoirs.

These alternatives were analyzed to address floodplain conditions and study objectives as outlined in the correspondence authorizing the study. Many questions have been raised following the 1993 flood concerning the impact levees have on flood stages. Questions have also been raised regarding the benefits of wetlands or other runoff reduction measures on reducing flood peaks. Various alternatives involving structural and nonstructural measures for the existing agricultural levees and upland retention/watershed measures were investigated. Evaluation of levee action alternatives focuses on agricultural levees because the vast amount of land protected by these levees offers the potential for storage of floodwaters. In most cases, limited opportunity for storage or conveyance of floodwater exists behind urban levees because of the relative size of the protected area compared to the cost of acquisition and relocation.

Scope of Hydrologic Model

While existing forms of flood protection reduced or prevented damages to many properties, these measures often proved inadequate to withstand the magnitude of flooding experienced during 1993. Within the hydraulic perspective, the assessment will focus on identifying facilities which require additional flood protection, assess the adequacy of current flood control measures, and evaluate alternatives to the current flood control system. In response to hydraulic requirements of the FPMA, development of a comprehensive system-wide modeling tool of the Missouri River, Mississippi River, and significant tributaries was required.

An unsteady flow modeling tool was necessary to adequately evaluate floodplain management and assessment alternatives on a system-wide basis. An unsteady flow model is suited for evaluating long reaches of rivers where the dynamic effects of levee breaches, backwater conditions, shallow bed slopes, and varying flow rates along the river are important. An unsteady flow model was constructed of the Mississippi and Missouri Rivers and significant tributary rivers. Corps District offices along the Mississippi River include St. Paul, Rock Island, and St. Louis. Corps District offices along the Missouri River include Omaha and Kansas City. While coordinated with all involved Corps Districts, each unsteady flow model was developed independently. System-wide routing was then performed for all conditions examined between adjacent Districts.

The development of a system-wide unsteady flow model was a critical element of the FPMA hydraulic analysis which required substantial effort. Prior to this effort, a single system-wide model of sufficient accuracy was not available which would allow an impact assessment of a variety of structural and nonstructural measures. Employing the unsteady flow model, many different alternatives were assessed system-wide to determine how the 1993 flood would have changed. FPMA alternatives analysis sometimes resulted in unexpected consequences and illustrated the need for thoroughly investigating all effects of any proposed modification to the existing system.

Unsteady Flow Model

The mathematical computer model program UNET, developed and programmed by Dr. Robert Barkau, was chosen as the tool to perform the FPMA unsteady flow modeling. UNET is a one-dimensional, unsteady flow program which simulates unsteady flow through a full network of open channels and reservoirs. Unsteady flow routing accounts for the variation in flow with both time and space. UNET is considered a complete dynamic wave model since it solves the full St. Venants equations of momentum and continuity. The UNET unsteady flow model was used for the FPMA analysis because it has the ability to account for the timing of tributary inflows, critical backwater effects in the routing, simulation of volume reduction caused by levee overflow or breaching, and the effects of storage within the floodplain.

An important feature of the UNET model for modeling the 1993 event is the simulation of levee overtopping or breaching and the transfer of flow from the main river into the storage area behind the levee. Within UNET, the usual levee algorithm simulates levee systems as storage cells defined by parameters which describe the stage-storage relationship of the protected area. In 1993, many of the agricultural levees within the Kansas City District overtopped as flood stages exceeded the design height of the levees by several feet. On the third and highest flood crest, virtually all agricultural levees were overtopped and there was significant overbank flow. Breached or overtopped levees were observed to function under two geometric conditions: one in which levees constrained the flow to the channel, but provided storage behind the levees; and the second in which the levees no longer constrained the flow, and the overbank actively conveyed water as if the levees did not exist. Therefore, Dr. Barkau developed a new levee algorithm for the UNET program which, based on discharge conditions, simulates levees as storage cells or routes flow through the entire width of the floodplain.

UNET Model Development

Separate UNET models were developed by each of the involved Corps Districts and linked together to provide a systemic modeling tool. UNET modeling was performed on the Mississippi River from Lock and Dam 10 at Guttenberg, Iowa, river mile (RM) 615.0, downstream to Cairo, Illinois, RM 0.0. Modeling on the Missouri River extended from Gavins Point Dam, at RM 811.1, downstream to the confluence with the Mississippi River. Numerous major tributaries were also included within the UNET models as routing reaches. Along the Missouri River reach, the UNET models combine for a total of 811 main stem river miles, in excess of 20 tributary routing reaches with a combined length of over 470 river miles, and a total number of cross sections in excess of 2,000. Along the Mississippi River reach, the UNET models combine for a total of 615 main stem river miles, more than 20 tributary routing reaches with a combined length of over 500 river miles, and a total number of cross sections in excess of 1,500. Refer to the Hydraulics and Hydrology appendix (Appendix A) for additional infomation regarding UNET model development.

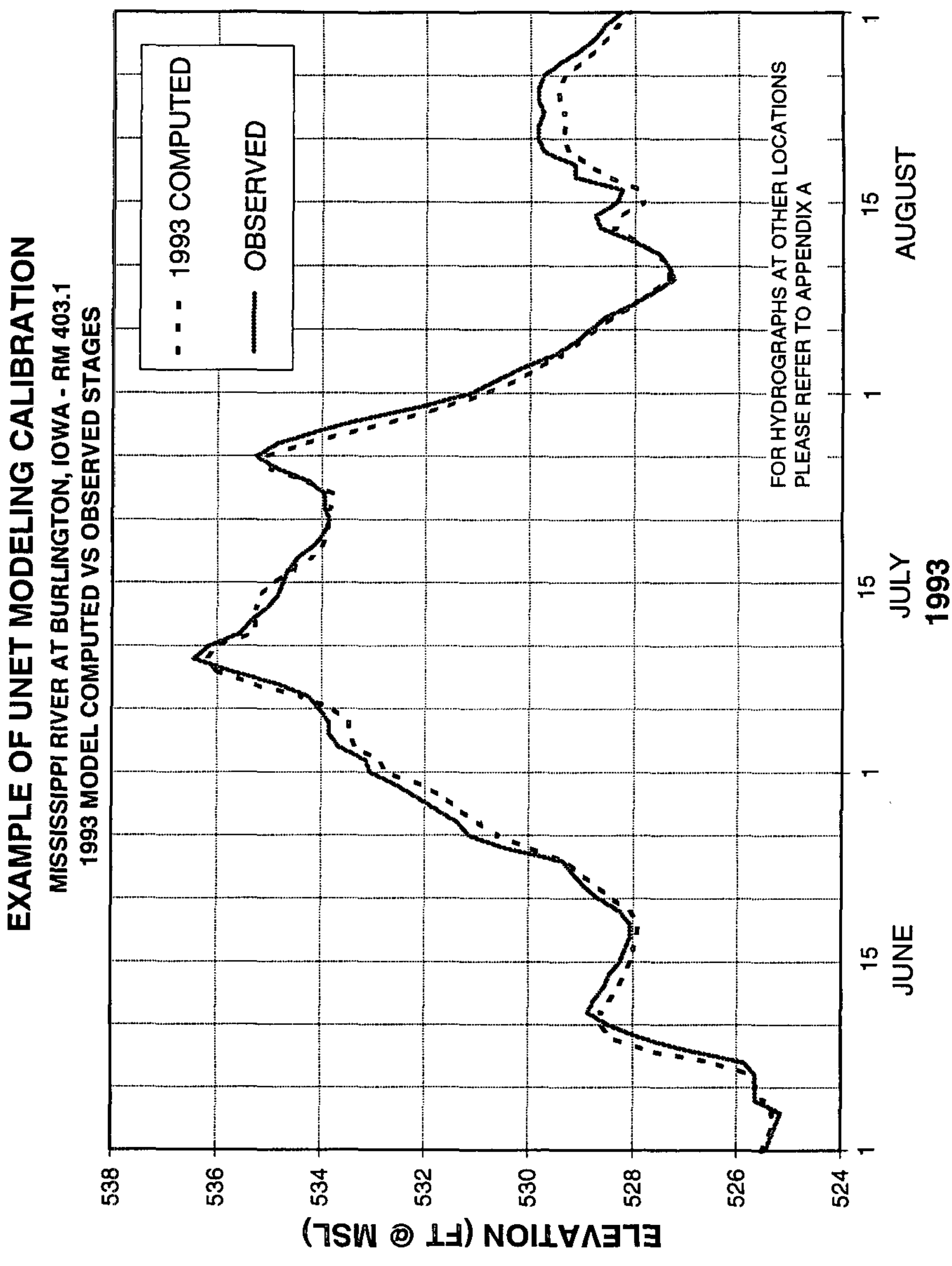
1993 Event. Base condition and alternative analysis focused on the 1993 event. Simulation of the 1993 event with the unsteady flow model was complicated by the wide variation in discharge within the modeled reach. Within the main stem river reaches modeled, estimated flood frequency varied from 10-year to in excess of 500-year. Peak discharge observed at U.S. Geological Survey (USGS) gaging stations within the Missouri River modeling reach ranged from 115,000 cubic feet per second (cfs) at Omaha, Nebraska, to 750,000 cfs at Hermann, Missouri. The wide variation in discharge illustrates the importance of correctly simulating tributary inflows with an unsteady flow model.

Model Geometry. Model geometry was compiled from available sources. No additional data was collected during the FPMA for purposes of enhancing model accuracy. Main stem channel geometry was generally developed from existing cross section data. Overbank geometry was taken from USGS 7.5-minute quad sheets in most cases and additional survey data where available. Most Missouri River channel geometry was compiled from survey data collected in the 1970's. Tributary geometry employed within the UNET models was generally taken from USGS 7.5-minute quad sheets or actual survey data where available. Cross section interval within the four UNET models varies from 0.2 mile to 2.0 miles.

Model Inflow. UNET model inflow consisted of USGS gaged inflows and estimated local inflow representing ungaged drainage area. Separate tributary routing reaches were included to route tributary flow from the USGS gaging station downstream to the main stem river. Among the four UNET models, in excess of 100 inflow hydrographs were used.

Calibration. The UNET model developed by each District was calibrated to the 1993 flood and other major flood events. Calibration efforts focused on reproducing 1993 observed stage hydrographs at gaging stations along the main stem river and verifying with discharge measurements. Calibration parameters within the UNET model allow the variation of conveyance with depth. Calibration was performed for the entire range of discharge experienced during the 1993 event to reproduce observed hydrographs for the time period June 1 to September 1. The calibration effort focused on reproducing peak stages. Calibration efforts were very successful with reproducing observed hydrograph shape. The calibrated model reproduced observed peak stages within 0.3 foot at most locations. A representative plot comparing observed and computed UNET model stages is shown on Figure 8-1. Additional data and plots related to calibration are included within the Hydrology and Hydraulics appendix. The calibrated model represents the base condition for the comparison of all alternatives.

Systemic Analysis. UNET analysis was performed on a system-wide basis encompassing the lower Missouri River and middle and upper Mississippi River basins. In order to conduct a continuous systemic analysis, it is necessary to transfer stage and flow data between UNET models. Data transfer locations between Corps Districts (and UNET models) were selected based on availability of dependable gage data, Corps District boundaries, backwater conditions, and cross section geometry. Geometry data within the upstream UNET model overlapped the downstream UNET model to eliminate the influence of the downstream boundary condition on computed results at the transfer location. Transfer locations between UNET models were, on the Mississippi River, at Lock and Dam 22 tailwater (RM 301.1) and, on the Missouri River, at St. Joseph, Missouri (RM 448.2), and Hermann, Missouri (RM 97.9).



EXAMPLE OF UNET MODELING CALIBRATION
MISSISSIPPI RIVER AT BURLINGTON, IOWA - RM 403.1
1993 MODEL COMPUTED VS OBSERVED STAGES
1993 COMPUTED
OBSERVED
FOR HYDROGRAPHS AT OTHER LOCATIONS
PLEASE REFER TO APPENDIX A
ELEVATION (FT @ MSL)
538
536
534
532
530
528
526
524
1
15
JUNE
1
15
JULY
1
15
AUGUST
1
1993

Figure 8-1

Levee Modeling. Simulation of the 1993 event with the unsteady flow model was complicated by the breaching and overtopping of numerous Federal and private levees at various times during 1993. Levees in the base condition model include height added to the levee crown during floodfight operations. Although the additional levee height in many cases did not prevent levee breaching or overtopping during the 1993 flood, it did affect the timing at which it occurred. Had additional height not been added to the levees, overtopping would have occurred much earlier in the event. Levee breaches in the base condition model were reproduced on the dates and times they actually occurred when data was available. When the actual timing of levee breaching was not available, the timing was estimated based on gage data. In all other alternatives modeled, levee overtopping was dependent on the relationship between the levee crown elevation and the water surface elevation of the river. Timing of levee breaching or overtopping plays an important role in determining the effects levees have on flood stages. Levees which breach close to the peak of the event may have a substantial impact on flood stages. Results of the base condition analysis closely matched the 1993 flood event and indicate that the UNET model successfully computed the impact of levee breach or overtopping on main stem river flows and stages.

DESCRIPTION OF SYSTEMIC ALTERNATIVES

Agricultural levee alternatives include levee removal, levee setback, levee confinement to contain the 1993 event and altering levees to provide only a 25-year level of protection. Systemic upland retention/watershed measures include no Federal reservoirs and runoff reductions of 5 percent and 10 percent. All the above alternatives were system-wide and included passing flow and stage information from upstream Districts to downstream Districts. Impact study reach evaluations were also completed for several isolated reaches which examined alternatives such as revised reservoir operation and floodfighting. Those evaluations are discussed in detail later in this chapter. Figures 8-2 through 8-13 show the flood extent of the base condition and the system-wide alternatives at two locations within the study area.

Agricultural Levee Alternatives. The effects of several alternative agricultural levee heights and locations were analyzed employing calibrated UNET models developed for the base condition. Geometry of urban levees was not modified. For each alternative, the base condition UNET model was modified to reflect geometry changes required to simulate the effect on conveyance within the model. Calibration parameters determined in the base condition were not altered for any of the alternatives. Modification of the UNET model geometry was necessary for each of the agricultural levee alternatives. Since no Federal agricultural levees exist either upstream of Omaha, on the Missouri River, or upstream of Lock and Dam 10 on the Mississippi River, only the UNET models downstream of these locations were used to assess the systemic alternatives.

Levee Removal Alternative. For this alternative, all agricultural levees were removed. Selection of roughness values for the flow area after the levee has been removed has major impacts on computed results. Effective flow width assumed for each cross section following levee removal is also important. Simulations were performed with both a minimum and maximum roughness value for the overbank area.

Roughness values were selected to provide a reasonable lower and upper bound for computed results. Various forms of land use within the overbank such as farming and natural habitat will have considerably different roughness values. Levee removal will remove channel constraints such that channel meandering and overbank sediment deposition may actually reduce channel conveyance. The roughness values chosen for the area between the existing agricultural levees and the bluff represent a low value for agricultural conditions and a high value for natural or forested conditions. Land use between the river and the existing levee was assumed to remain the same as it is now. Variation in channel roughness was not examined. If levees were removed and the channel was no longer maintained for navigation, channel roughness values may increase as the river adapts to the change.

Removing the levee provides significant additional flow area since cross sections are generally several miles wide. However, removal of the levee would not result in an effective flow width equal to the entire valley width. Physical factors such as channel meandering, vegetation, topography, structures such as roads and railroads, and other components will restrict effective flow width to a value much less than the cross section width. Due to the numerous natural and constructed obstructions within the conveyance area, effective flow width is much less than the cross section width. As a result, the no levee UNET model would overstate the available flow area when the levee flow constriction is removed from the cross section. However, the roughness values used in the model were adjusted to account for those ineffective flow areas.

Modifying the UNET model to accurately reflect the conveyance changes at every cross section was not practical for this assessment. Therefore, effective flow width and other factors which reduce cross section conveyance were included in the UNET model by adjusting roughness values. Manning's n values were increased from 0.04 for agricultural land use to 0.08 and from 0.16 for a natural wooded floodplain to 0.32. This adjustment is the same as reducing the overbank effective flow area by 50 percent. A roughness value adjustment does not reduce the area available for overbank flood storage. Because of these assumptions, computed results for the levee removal alternative should be regarded as estimates. More precise and accurate simulation of this alternative would require the construction of an entirely new model and detailed studies to determine the long-term effects of vegetation and sedimentation within the floodplain on conveyance.

Cost analysis performed for removal of the existing levee assumed that 10 percent of the existing levee would be removed to provide sufficient conveyance beyond the existing levee alignment. A figure of 10 percent corresponds to removal of approximately a 200-foot levee segment within every 2,000 feet. Actual levee removal areas would be site specific, dependent on channel and levee alignment.

Levee Setback Alternative. The UNET model was employed to analyze the effect on flow conditions throughout the study reach for a systemic setback of all agricultural levees on the middle and upper Mississippi and lower Missouri Rivers. Setback of a levee refers to moving the levee from the present location to a new location which is farther from the river. Levee setbacks are intended to increase the cross section flow width instead of constricting the flow area to a narrow channel. Effects of levee setbacks in limited reaches are discussed in the Case Studies section of this chapter.

Levee setback distance was performed by adjusting the minimum distance between left and right bank levees, or the bluff line, to increase the floodway width. Minimum floodway width was set at 5,000 feet or increased to 150 percent of the existing floodway width in some locations. Setback levee height was maintained at the existing levee height.

Alternative Variation. A variation on this alternative was modeled for the middle and upper Mississippi River. This variation assumed the agricultural levees were set back as described above, but were raised high enough to prevent overtopping by the 1993 flood event. This resulted in changes of stage of -1.4 feet at Lock and Dam 16, -0.6 foot at Burlington, +1.6 feet at Quincy, +2.8 feet at Hannibal, -0.5 foot at Grafton, and -0.5 foot at St. Louis. Refinement of this alternative could result in higher or lower stages at any of these locations. Additional details on this alternative are provided in Appendix A.

Levee Confinement Alternative. For this alternative, all agricultural levees were raised infinitely high such that the 1993 flood event was confined to the area between the existing levees. All existing levees were raised regardless of the current level of protection. Levee locations or roughness values were not altered for this alternative. An additional 3 feet to account for risk and uncertainty was added to the confined water surface elevation for the construction levee height when performing cost analysis. This alternative is the same as the "Raising Levees above the 1993 Flood Levels" alternative evaluated in Chapter 9.

Levee Height at 25-year Level Alternative. For this alternative, the height of all agricultural levees was set to correspond with an estimated 25-year profile based on previous hydrology. Federal levees, which are currently higher than the 25-year elevation, were notched to an elevation equal to the 25-year elevation. Levees which are lower than the 25-year level were raised to the 25-year elevation. The levee notch was designed as an erodible plug. When flood levels exceed the 25-year level, the levee notch is eroded and the cell fills with water. In this manner, the levee cells along the channel act as detention basins to store water when river elevations exceed the 25-year elevation.

Each levee cell was assumed to include a constructed notch at the upstream and downstream ends. The notch would consist of a lowered section which would act as a fuse plug of erodible material. The notch would consist of an erodible core material overlain with a top layer. The notch would be designed to erode in a non-catastrophic manner. The downstream notch would be constructed at the 25-year elevation. The upstream notch would be constructed at the 25-year elevation plus 3 feet. Levees that must be raised (are currently below the 25-year level) should be constructed at the 25-year elevation without any freeboard. For UNET modeling purposes, all breaches and overtoppings assumed that the erodible plug would function such that the interior levee cell would fill in a 24-hour period. The hydraulics and hydrology appendix shows levee data used in the UNET model.

Upland Retention/Watershed Measures

Various policy and structural measures exist which may affect inflow rates to the river system. The UNET model was employed to investigate system performance for different upland retention and watershed measures. For the evaluation of these measures, no modifications to UNET model geometry were performed. Assessment was performed by adjusting inflow hydrographs to the UNET model for each scenario examined.

5 and 10 Percent Runoff Reduction. For this alternative, measures which would reduce the total runoff volume during the 1993 flood were evaluated by reducing main stem and tributary inflow hydrographs to the model by both 5 and 10 percent. Based on the St. Paul District's preliminary studies of wetland storage and other upland retention measures, it was estimated that the maximum available storage with 1993 flood antecedent conditions would reduce the total runoff volume into the Mississippi and Missouri Rivers between 5 and 10 percent. Depending on individual drainage basin characteristics, some tributary basins could store more than 10 percent of the basin runoff volume, and some tributary basins have little or no upland retention storage available. To simplify the UNET modeling, all the inflow hydrographs were reduced by an equal percentage. Also, in reality, runoff reduction would not be distributed equally over the total inflow hydrograph but instead would have a major impact on the shape of the inflow hydrograph at the beginning of the 1993 event and would have little or no impact on the peak discharges and stages on the river.

Without Federal Reservoirs. Simulation of this alternative was performed to assess the effect of Federal reservoirs on the 1993 event. Large

Federal reservoirs which significantly affected river flows include the six main stem dams on the Missouri River and in excess of 40 dams on tributaries within the UNET model reach. The without reservoir hydrographs were computed by the Reservoir Control Centers and were used as UNET model inflow instead of the 1993 observed hydrographs with reservoir holdouts. All other parameters were unchanged from the base condition.

SUMMARY OF SYSTEMIC HYDRAULIC ROUTINGS

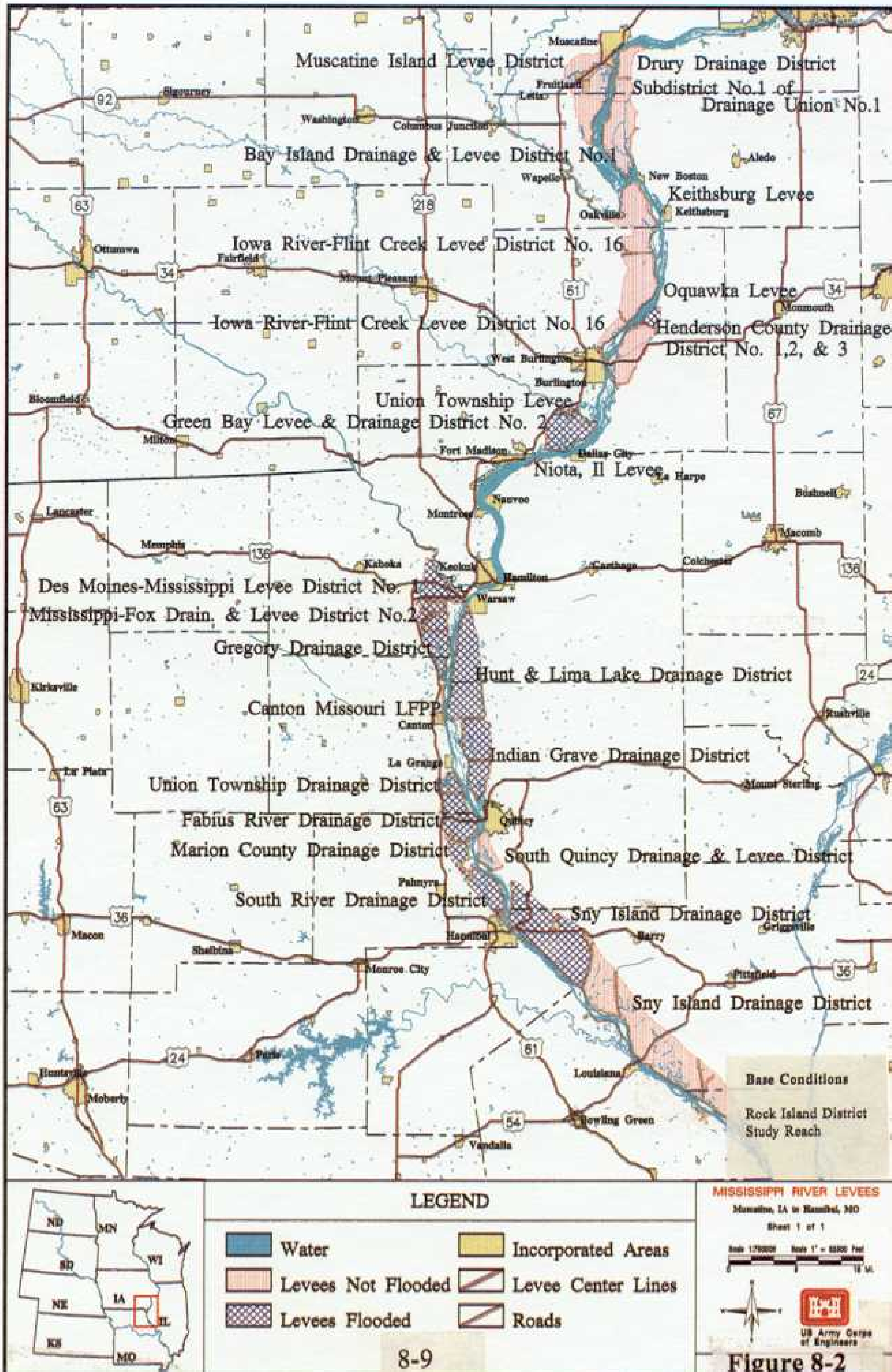
Output Formats

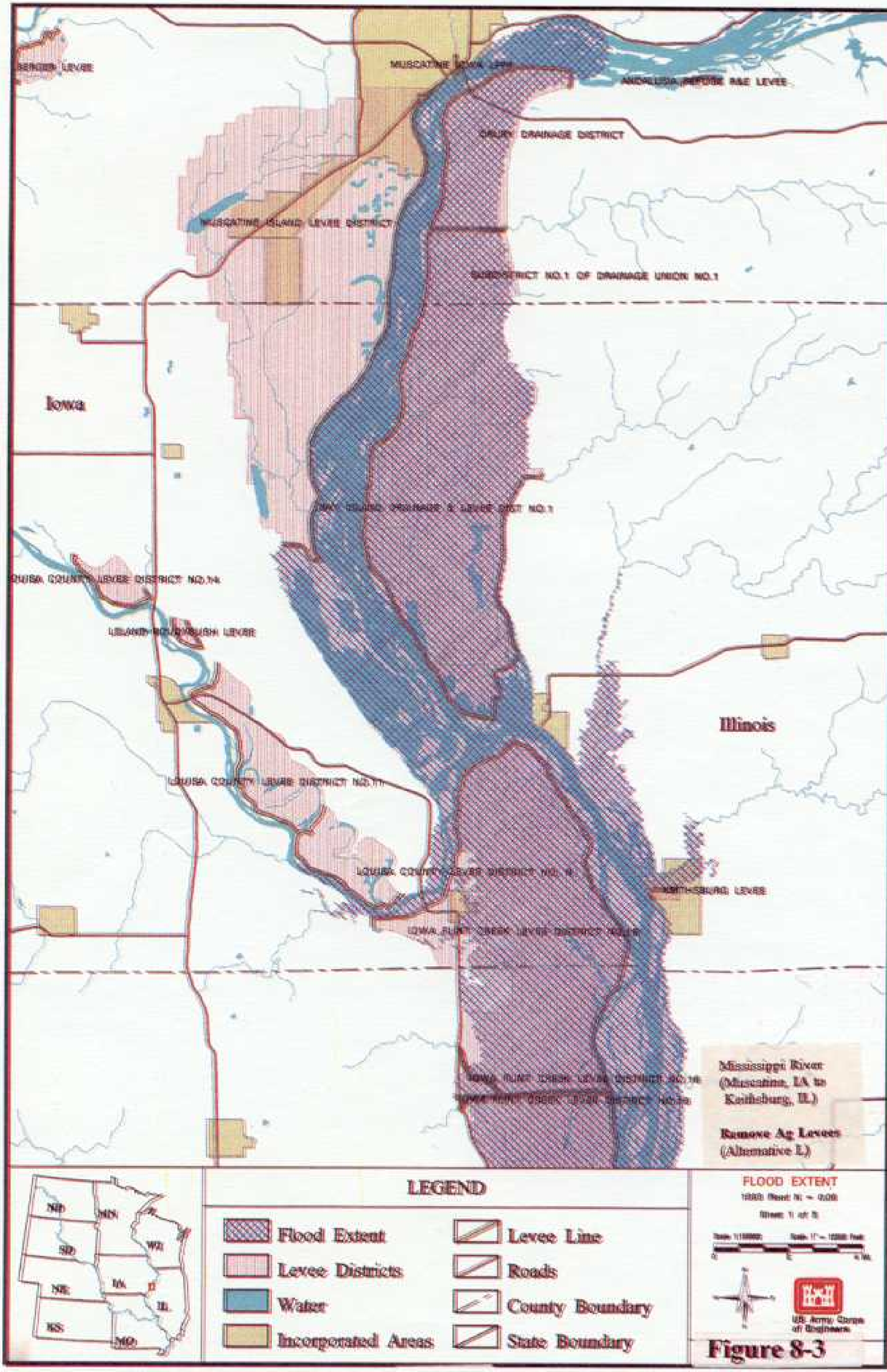
Output of the UNET model consists of hydrographs at specified locations, maximum flow and water surface elevation profiles for each reach, storage cell stage hydrographs, and levee connection flow hydrographs. Computed data from the UNET model was extracted and summarized to allow the evaluation of the base and alternative conditions. A graphical representation of Missouri River and cell peak stage variation from the base condition at selected locations is shown in the hydraulics and hydrology appendix.

Hydrographs. Plotted stage hydrographs at selected locations for the base condition and various alternatives are shown in the hydraulics and hydrology appendix.

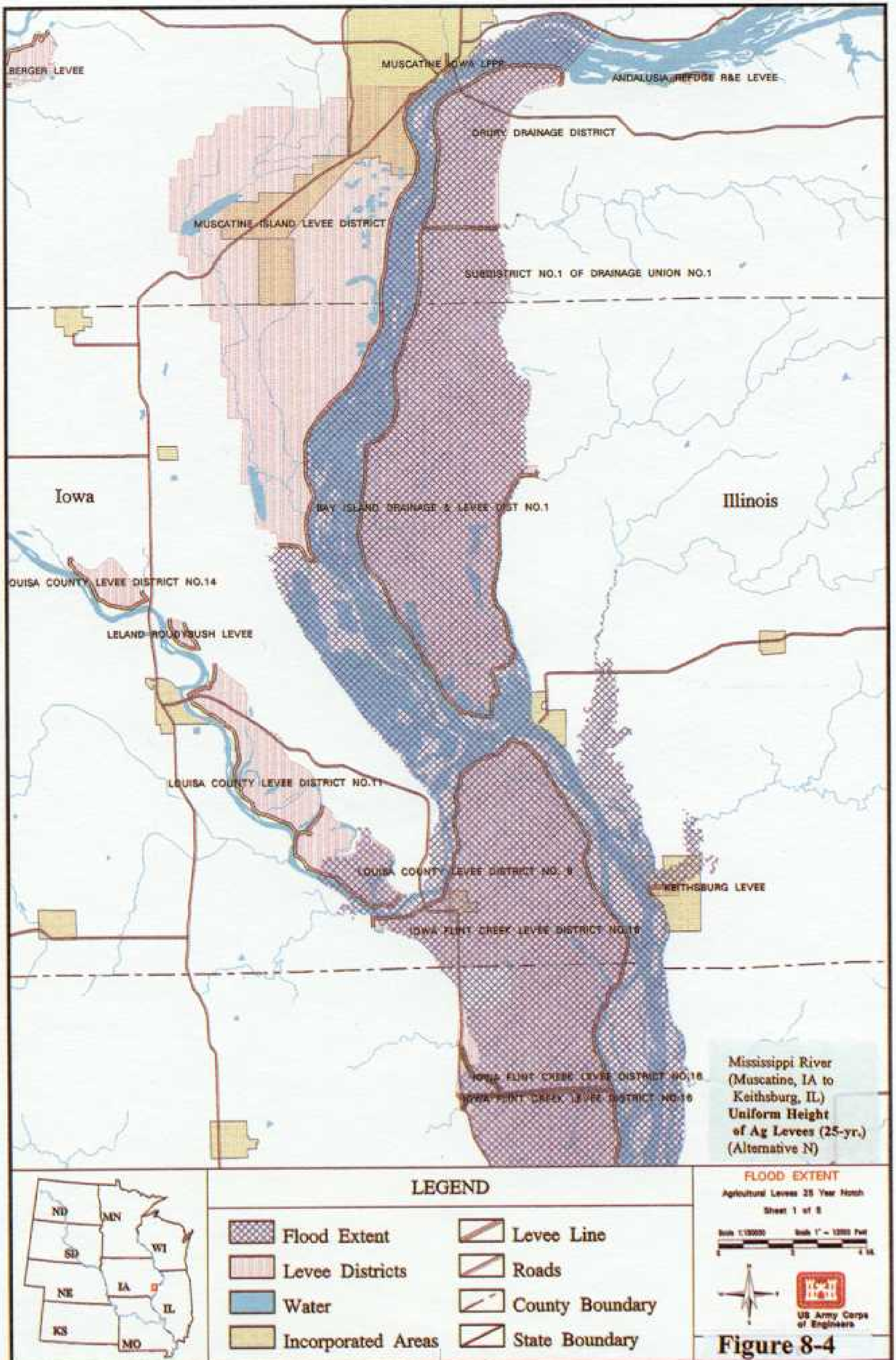
Peak Flow and Stage. A tabulation of Missouri and Mississippi River peak flows and stages for the base condition compared with various alternatives are shown in Tables 8-1 through 8-4. Additional locations are shown in the hydraulics and hydrology appendix. Tabulation location corresponds with the gaging station locations. Evaluation of any alternative must examine both flow and stage to consider all effects of the alternative.

Flood Boundaries. An approximate outline of flood boundaries was developed for each alternative. Examples of the flood boundaries for various alternatives for the Mississippi River for the reach between Muscatine and Hannibal are shown on Figures 8-2 through 8-7. Examples of the flood boundaries for various alternatives for the Missouri River for the reach between Omaha and Rulo are shown on Figures 8-8 through 8-13. Similar mapping of other reaches is available as described in attachment 8. Topographic representation of the study area was obtained from USGS 7.5-minute quadrangle topographic maps. Quad map contour interval varied from 5-foot to 10-foot. For areas behind the Federal levee cells, flood boundaries were determined using the peak stage determined within the levee cell by the UNET model. Interior drainage and local runoff were not modeled by UNET and not considered when determining flood boundaries. The density of available topography from the quadrangle sheets restricted the accuracy of the flood boundaries.


Muscatine Island Levee District
Drury Drainage District
Subdistrict No.1 of Drainage Union No.1
Bay Island Drainage & Levee District No.1
Keithsburg Levee
Iowa River-Flint Creek Levee District No. 16
Oquawka Levee
Iowa River-Flint Creek Levee District No. 16
Henderson County Drainage District No. 1,2, & 3
Union Township Levee
Green Bay Levee & Drainage District No. 2
Niota, Il Levee
Des Moines-Mississippi Levee District No. 1
Mississippi-Fox Drain. & Levee District No.2
Gregory Drainage District
Hunt & Lima Lake Drainage District
Canton Missouri LFPP
Indian Grave Drainage District
Union Township Drainage District
Fabius River Drainage District
Marion County Drainage District
South Quincy Drainage & Levee District
South River Drainage District
Sny Island Drainage District
Sny Island Drainage District
Base Conditions
Rock Island District Study Reach
LEGEND
Water
Incorporated Areas
Levees Not Flooded
Levee Center Lines
Levees Flooded
Roads
MISSISSIPPI RIVER LEVEES
Muscatine, IA to Hannibal, MO
Sheet 1 of 1
US Army Corps of Engineers
Figure 8-2



Iowa
Illinois
MUSCATINE ISLAND LEVEE DISTRICT
DISTRICT NO.1 OF DRAINAGE UNION NO.1
LOUISA COUNTY LEVEE DISTRICT NO.11
KEITHSBURG LEVEE
Mississippi River
(Muscatine, IA to
Keithsburg, IL)
Remove Ag Levees
(Alternative L)
LEGEND
Flood Extent
Levee Districts
Water
Incorporated Areas
Levee Line
Roads
County Boundary
State Boundary
FLOOD EXTENT
US Army Corps
of Engineers
Figure 8-3


BERGER LEVEE
MUSCATINE IOWA LFPP
ANDALUSIA REFUGE R&E LEVEE
DRURY DRAINAGE DISTRICT
MUSCATINE ISLAND LEVEE DISTRICT
SUBDISTRICT NO.1 OF DRAINAGE UNION NO.1
Iowa
Illinois
BAY ISLAND DRAINAGE & LEVEE DIST NO.1
LOUISA COUNTY LEVEE DISTRICT NO.14
LELAND ROUDYBUSH LEVEE
LOUISA COUNTY LEVEE DISTRICT NO.11
LOUISA COUNTY LEVEE DISTRICT NO. 8
KEITHSBURG LEVEE
IOWA FLINT CREEK LEVEE DISTRICT NO.16
IOWA FLINT CREEK LEVEE DISTRICT NO.16
IOWA FLINT CREEK LEVEE DISTRICT NO.16
Mississippi River
(Muscatine, IA to
Keithsburg, IL)
Uniform Height
of Ag Levees (25-yr.)
(Alternative N)
ND
MN
SD
WI
NE
IA
IL
KS
MO
LEGEND
Flood Extent
Levee Districts
Water
Incorporated Areas
Levee Line
Roads
County Boundary
State Boundary
FLOOD EXTENT
Agricultural Levees 25 Year Notch
Sheet 1 of 5
US Army Corps of Engineers
Figure 8-4

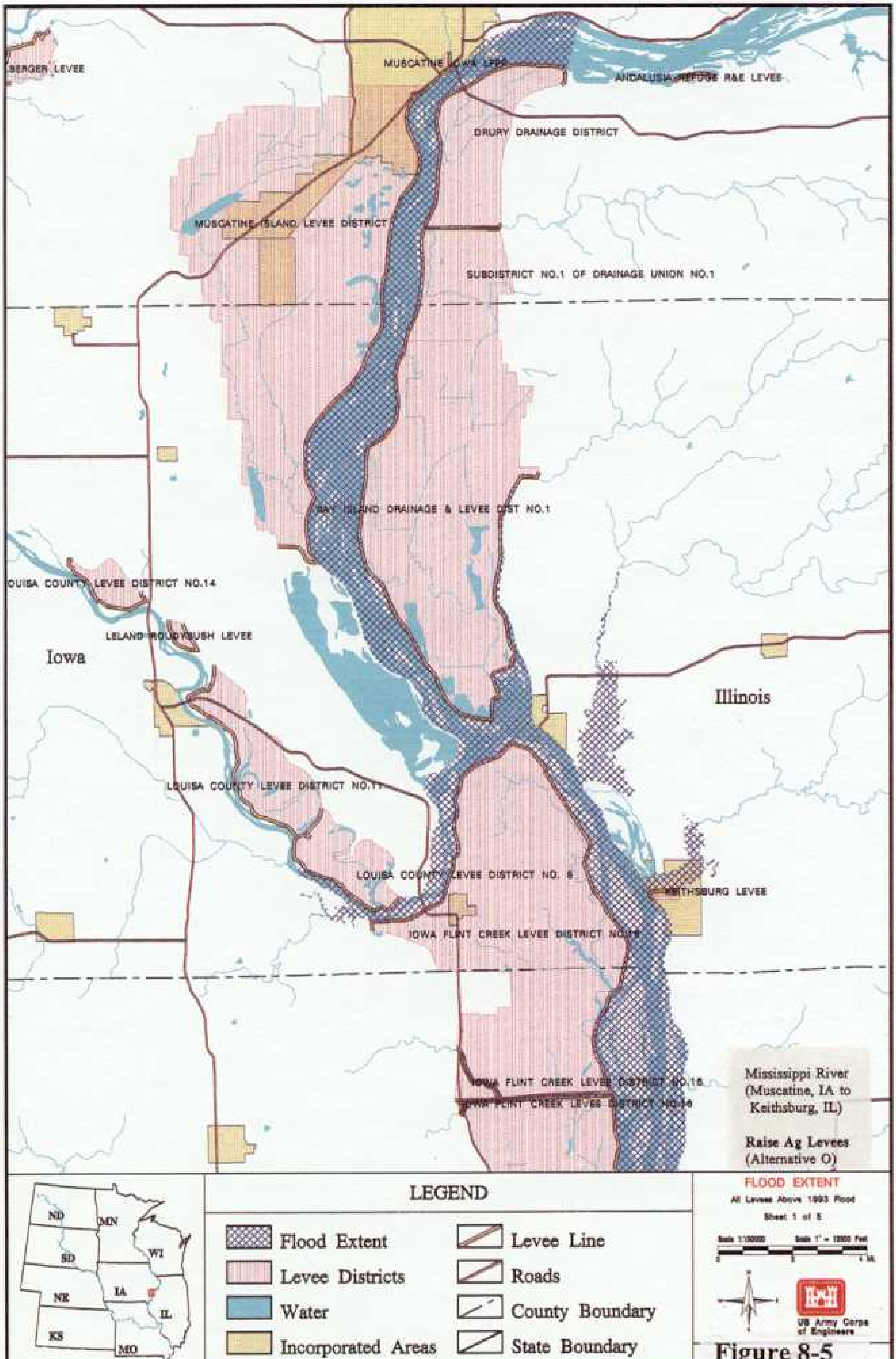

BERGER LEVEE
MUSCATINE IOWA LFPP
ANDALUSIA REFUGE R&E LEVEE
DRURY DRAINAGE DISTRICT
MUSCATINE ISLAND LEVEE DISTRICT
SUBDISTRICT NO.1 OF DRAINAGE UNION NO.1
BAY ISLAND DRAINAGE & LEVEE DIST NO.1
LOUISA COUNTY LEVEE DISTRICT NO.14
LELAND ROUDYBUSH LEVEE
Iowa
Illinois
LOUISA COUNTY LEVEE DISTRICT NO.11
LOUISA COUNTY LEVEE DISTRICT NO. 8
KEITHSBURG LEVEE
IOWA FLINT CREEK LEVEE DISTRICT NO.16
Mississippi River
(Muscatine, IA to Keithsburg, IL)
Raise Ag Levees
(Alternative O)
LEGEND
Flood Extent
Levee Districts
Water
Incorporated Areas
Levee Line
Roads
County Boundary
State Boundary
ND
MN
SD
WI
NE
IA
IL
KS
MO
FLOOD EXTENT
All Levees Above 1993 Flood
Sheet 1 of 5
US Army Corps of Engineers

Figure 8-5

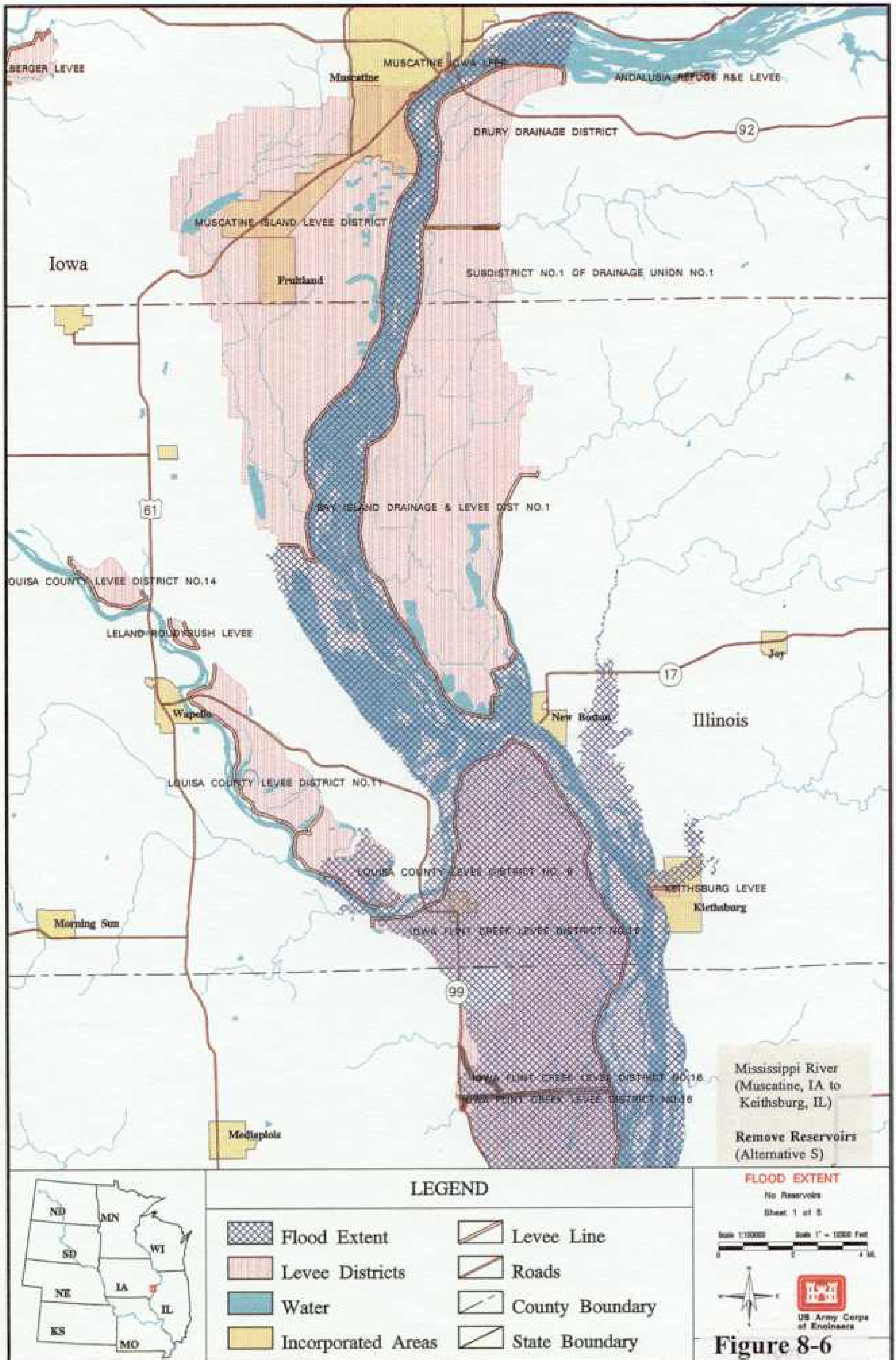
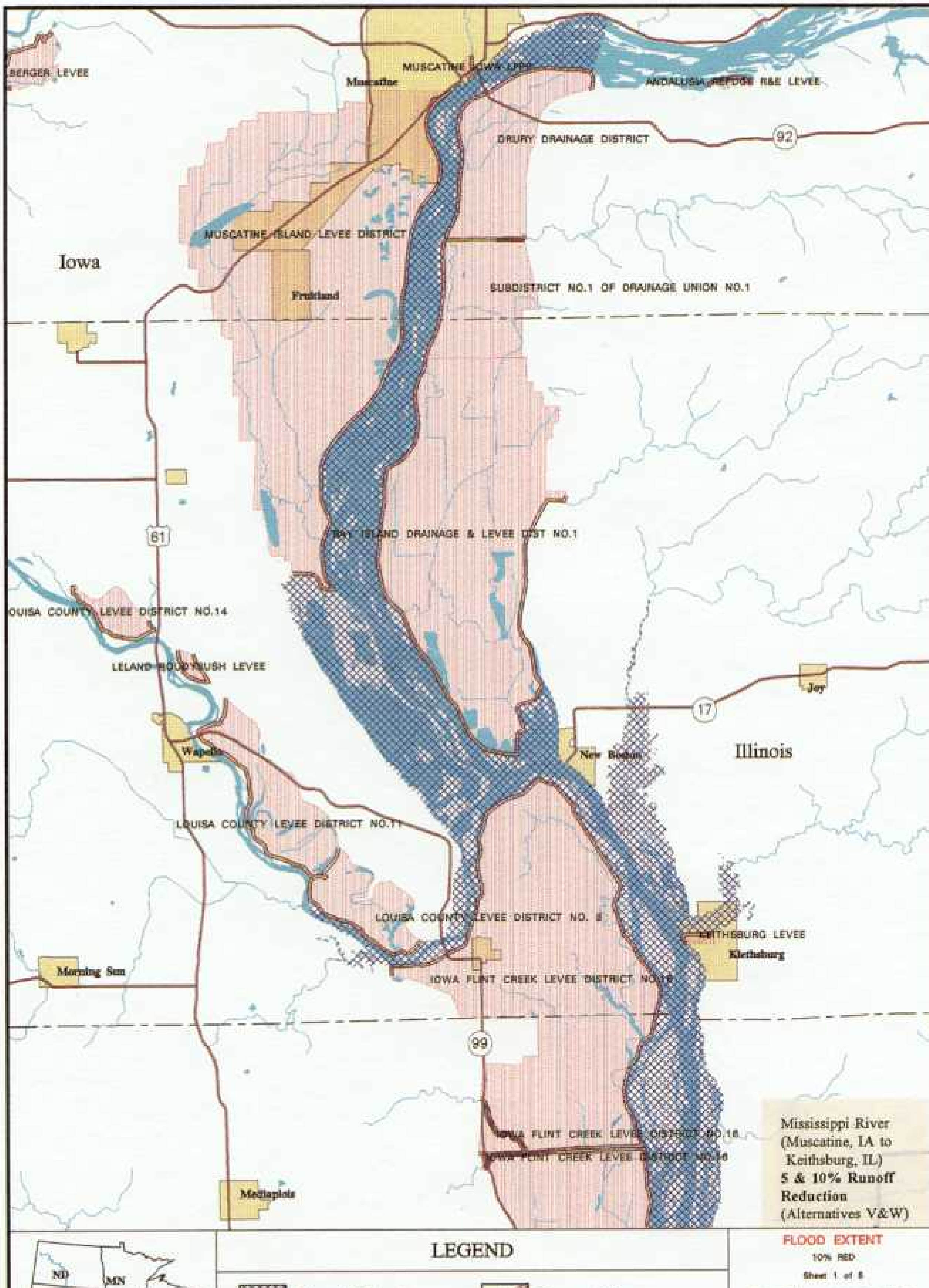

Iowa
Illinois
MUSCATINE IOWA LFEE
Muscatine
ANDALUSIA REFUGE R&E LEVEE
DRURY DRAINAGE DISTRICT
MUSCATINE ISLAND LEVEE DISTRICT
Fruitland
SUBDISTRICT NO.1 OF DRAINAGE UNION NO.1
BAY ISLAND DRAINAGE & LEVEE DIST NO.1
LOUISA COUNTY LEVEE DISTRICT NO.14
LELAND ROUDYBUSH LEVEE
Wapello
New Boston
Joy
LOUISA COUNTY LEVEE DISTRICT NO.11
LOUISA COUNTY LEVEE DISTRICT NO. 8
KEITHSBURG LEVEE
Kiethsburg
Morning Sun
Mediapolis
Mississippi River
(Muscatine, IA to
Keithsburg, IL)
Remove Reservoirs
(Alternative S)
LEGEND
Flood Extent
Levee Districts
Water
Incorporated Areas
Levee Line
Roads
County Boundary
State Boundary
FLOOD EXTENT
No Reservoirs
Sheet 1 of 5
US Army Corps
of Engineers
ND
MN
SD
WI
NE
IA
IL
KS
MO
61
92
17
99

Figure 8-6



Mississippi River (Muscatine, IA to Keithsburg, IL)
5 & 10% Runoff Reduction
(Alternatives V&W)

Figure 8-7

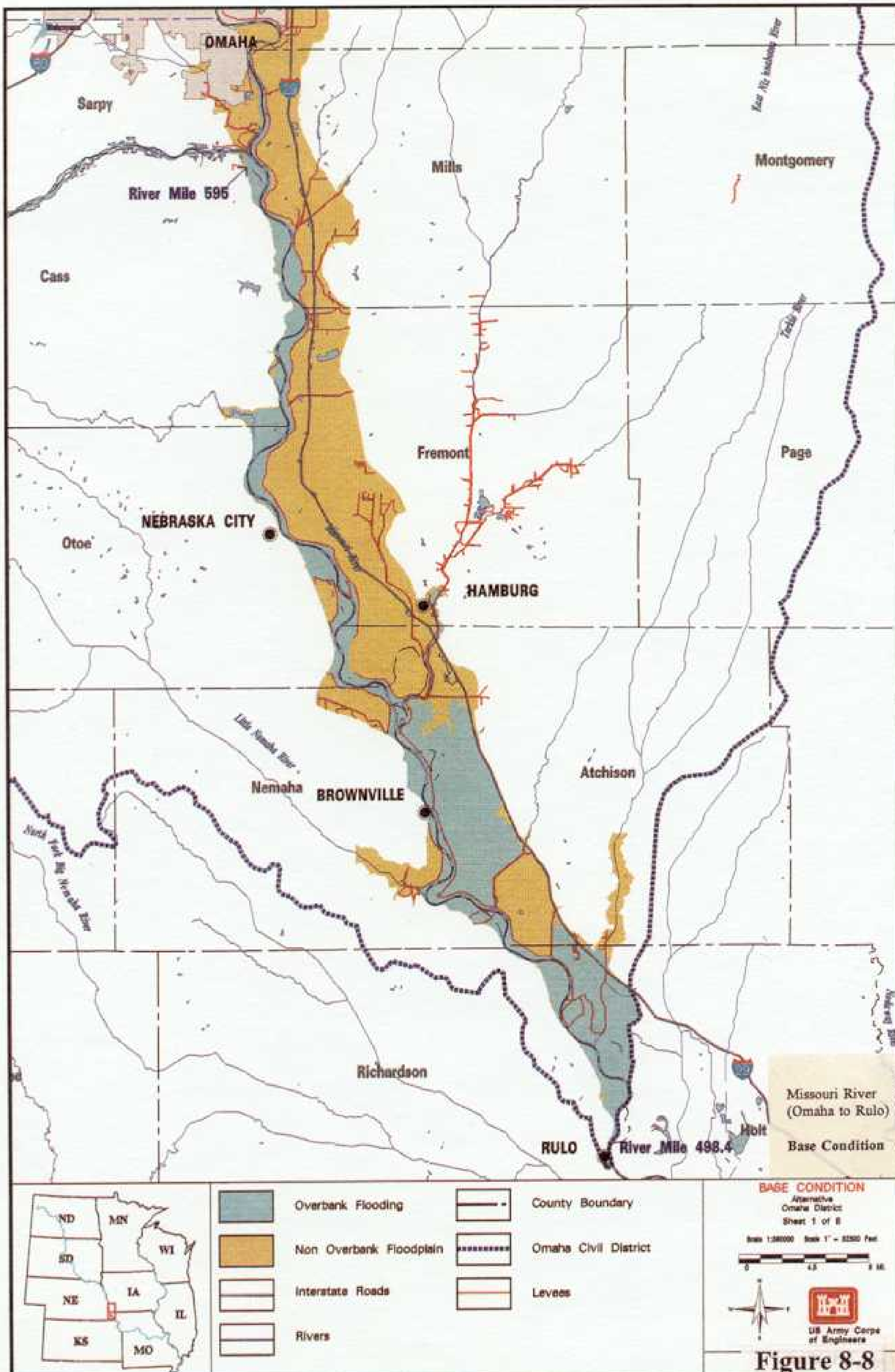
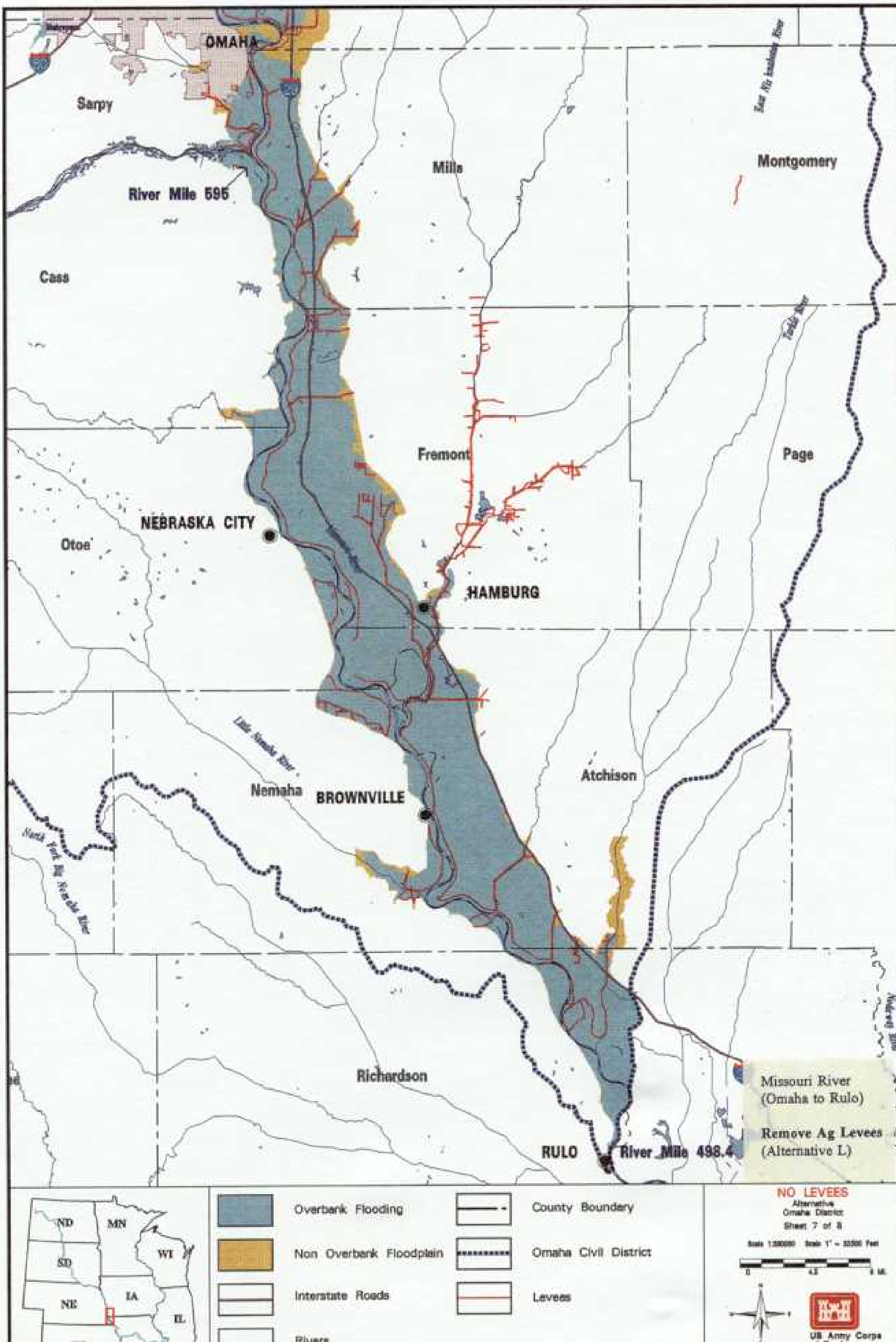

OMAHA
Sarpy
Mills
Montgomery
River Mile 595
Cass
Fremont
Page
NEBRASKA CITY
Otoe
HAMBURG
Atchison
Nemaha
BROWNVILLE
Richardson
RULO
River Mile 498.4
Holt
Missouri River
(Omaha to Rulo)
Base Condition
ND
MN
SD
WI
NE
IA
IL
KS
MO
Overbank Flooding
Non Overbank Floodplain
Interstate Roads
Rivers
County Boundary
Omaha Civil District
Levees
BASE CONDITION
Alternative
Omaha District
Sheet 1 of 8
US Army Corps of Engineers

Figure 8-8



OMAHA
Sarpy
Mills
Montgomery
River Mile 595
Cass
Fremont
Page
NEBRASKA CITY
Otoe
HAMBURG
Little Nemaha River
Atchison
Nemaha
BROWNVILLE
Richardson
RULO
River Mile 498.4
Missouri River
(Omaha to Rulo)
Remove Ag Levees
(Alternative L)
ND
MN
SD
WI
NE
IA
IL
KS
MO
Overbank Flooding
Non Overbank Floodplain
Interstate Roads
Rivers
County Boundary
Omaha Civil District
Levees
NO LEVEES
Alternative
Omaha District
Sheet 7 of 8
US Army Corps of Engineers

Figure 8-9

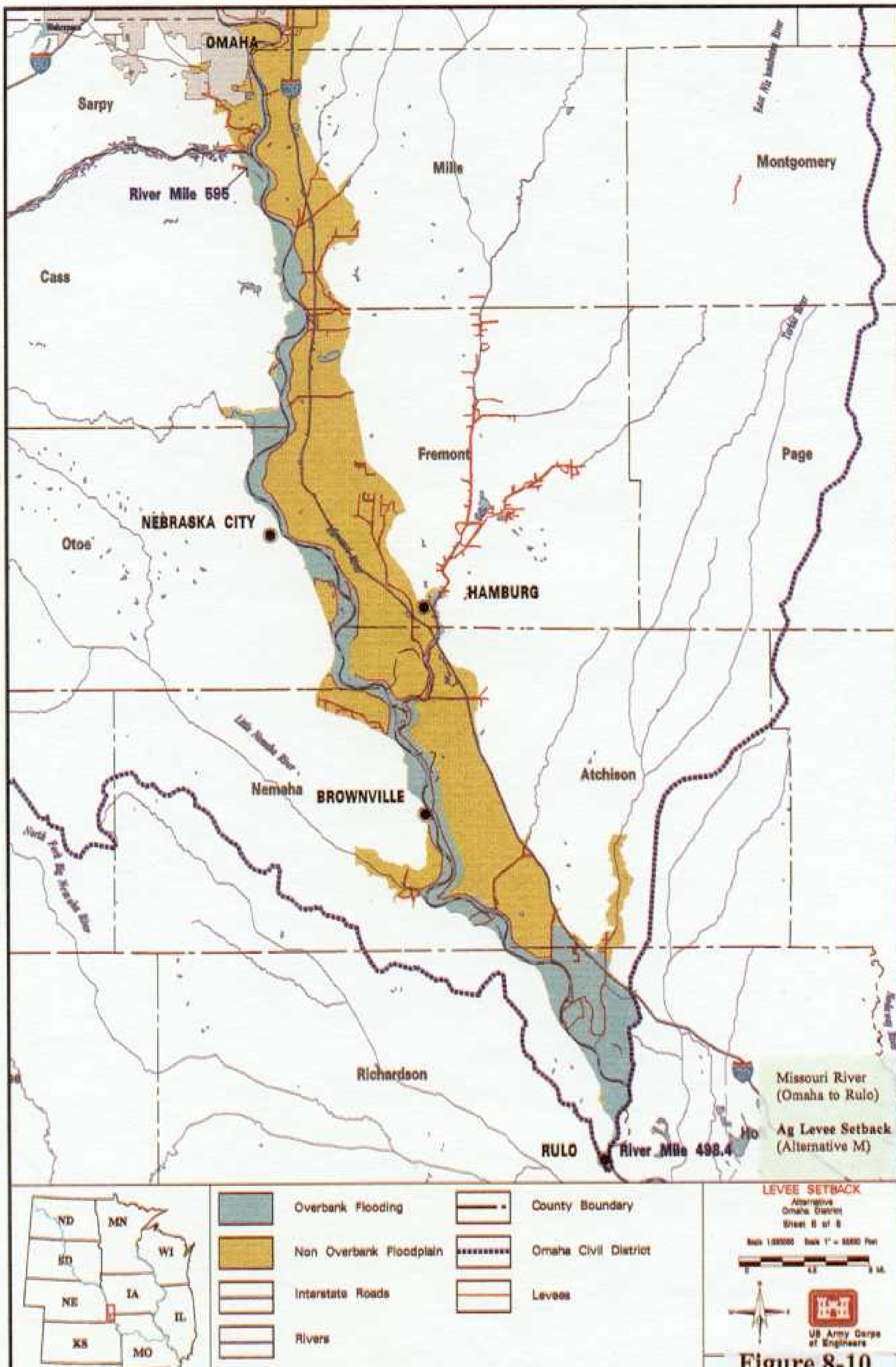
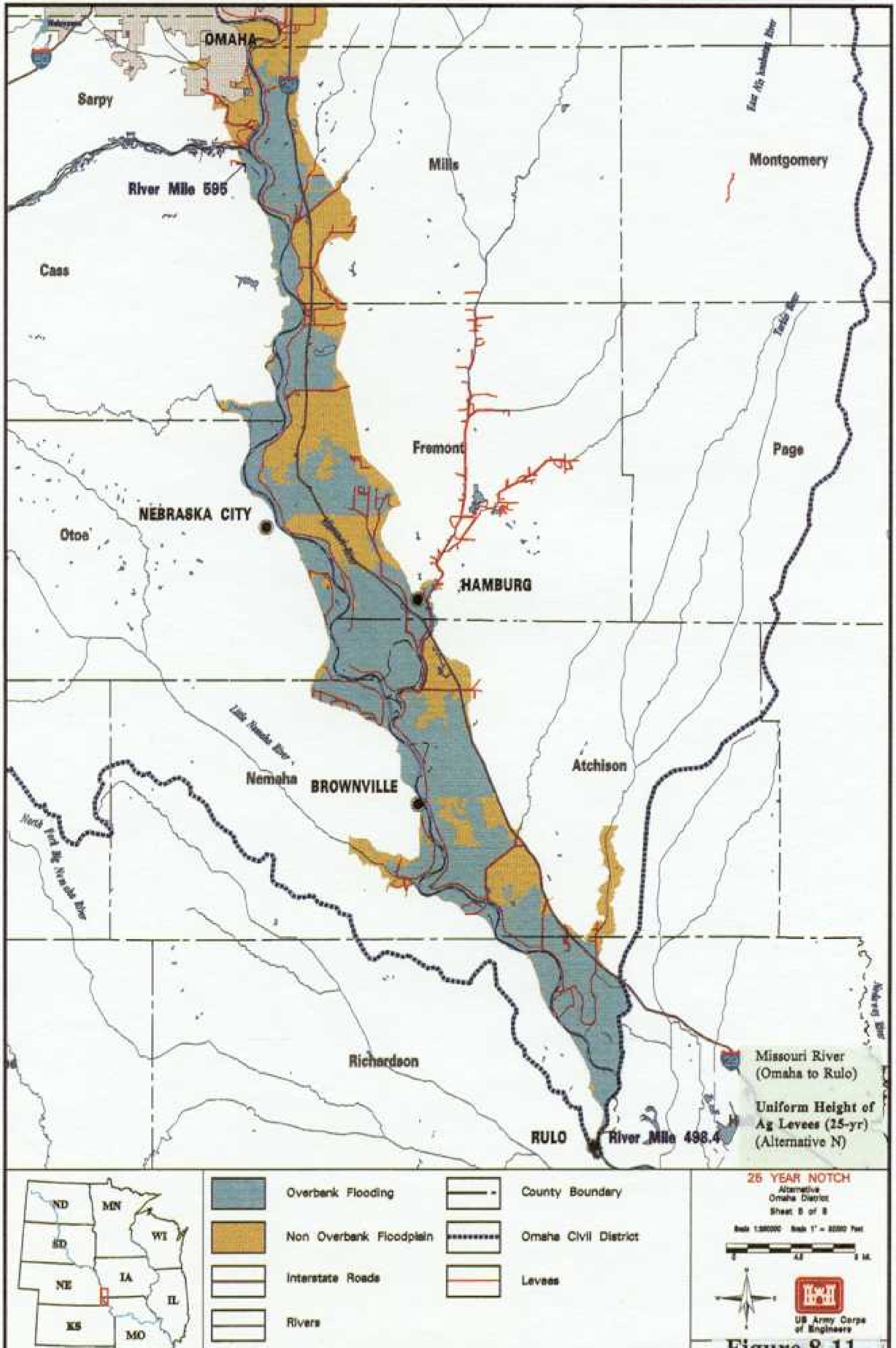

OMAHA
Sarpy
Mills
Montgomery
River Mile 595
Cass
Fremont
Page
NEBRASKA CITY
Otoe
HAMBURG
Atchison
Nemaha
BROWNVILLE
Richardson
RULO
River Mile 498.4
Missouri River
(Omaha to Rulo)
Ag Levee Setback
(Alternative M)
ND
MN
SD
WI
NE
IA
IL
KS
MO
Overbank Flooding
Non Overbank Floodplain
Interstate Roads
Rivers
County Boundary
Omaha Civil District
Levees
LEVEE SETBACK
US Army Corps of Engineers

Figure 8-10


OMAHA
Sarpy
Mills
Montgomery
River Mile 595
Cass
Fremont
Page
NEBRASKA CITY
Otoe
HAMBURG
Atchison
Nemaha
BROWNVILLE
Richardson
RULO
River Mile 498.4
Missouri River
(Omaha to Rulo)
Uniform Height of Ag Levees (25-yr)
(Alternative N)
ND
MN
SD
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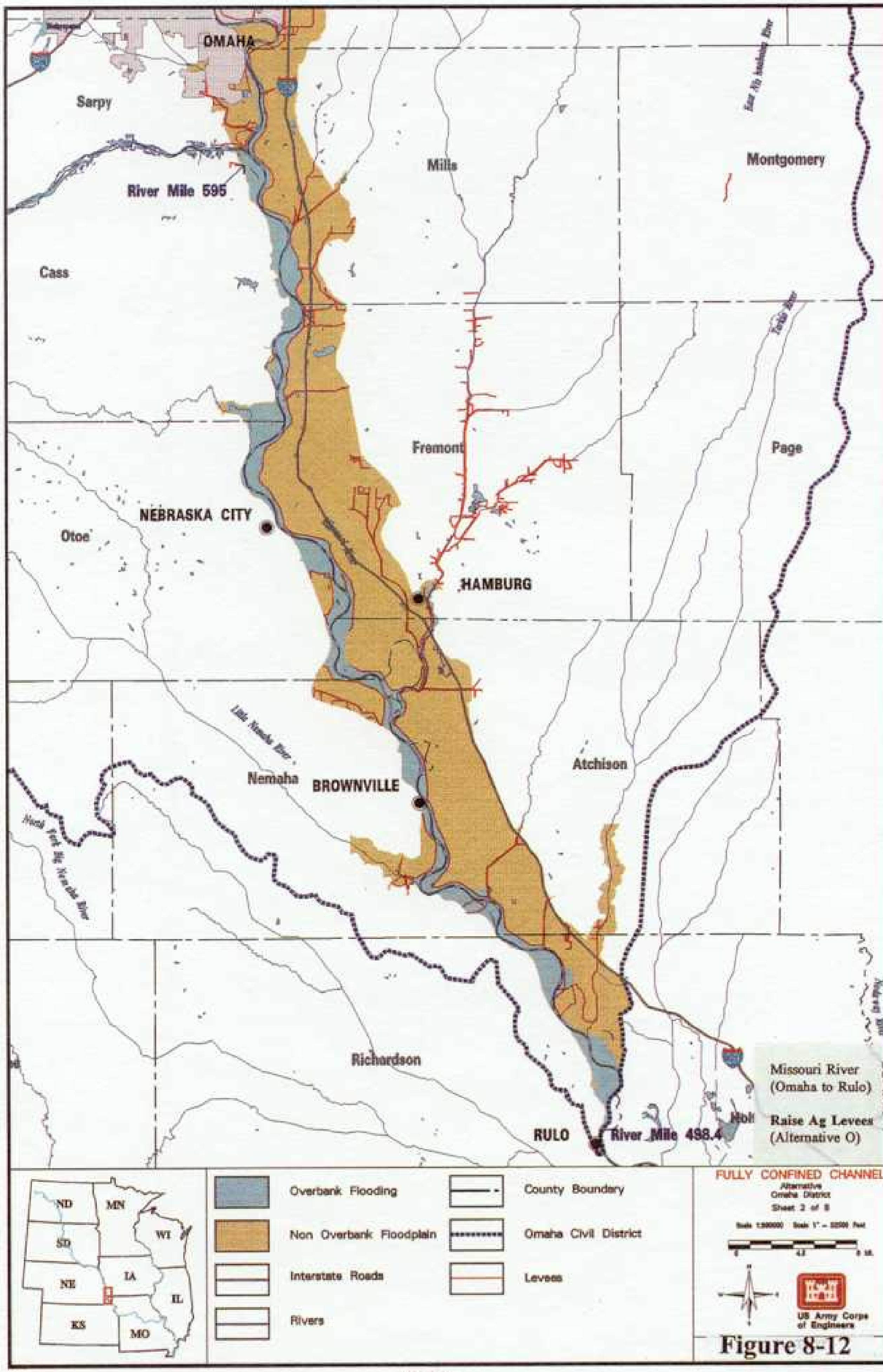
IA
IL
KS
MO
Overbank Flooding
Non Overbank Floodplain
Interstate Roads
Rivers
County Boundary
Omaha Civil District
Levees
25 YEAR NOTCH
US Army Corps of Engineers

Figure 8-11


OMAHA
Sarpy
Mills
Montgomery
River Mile 595
Cass
Fremont
Page
NEBRASKA CITY
Otoe
HAMBURG
Little Nemaha River
Atchison
Nemaha
BROWNVILLE
Richardson
RULO
River Mile 498.4
Missouri River
(Omaha to Rulo)
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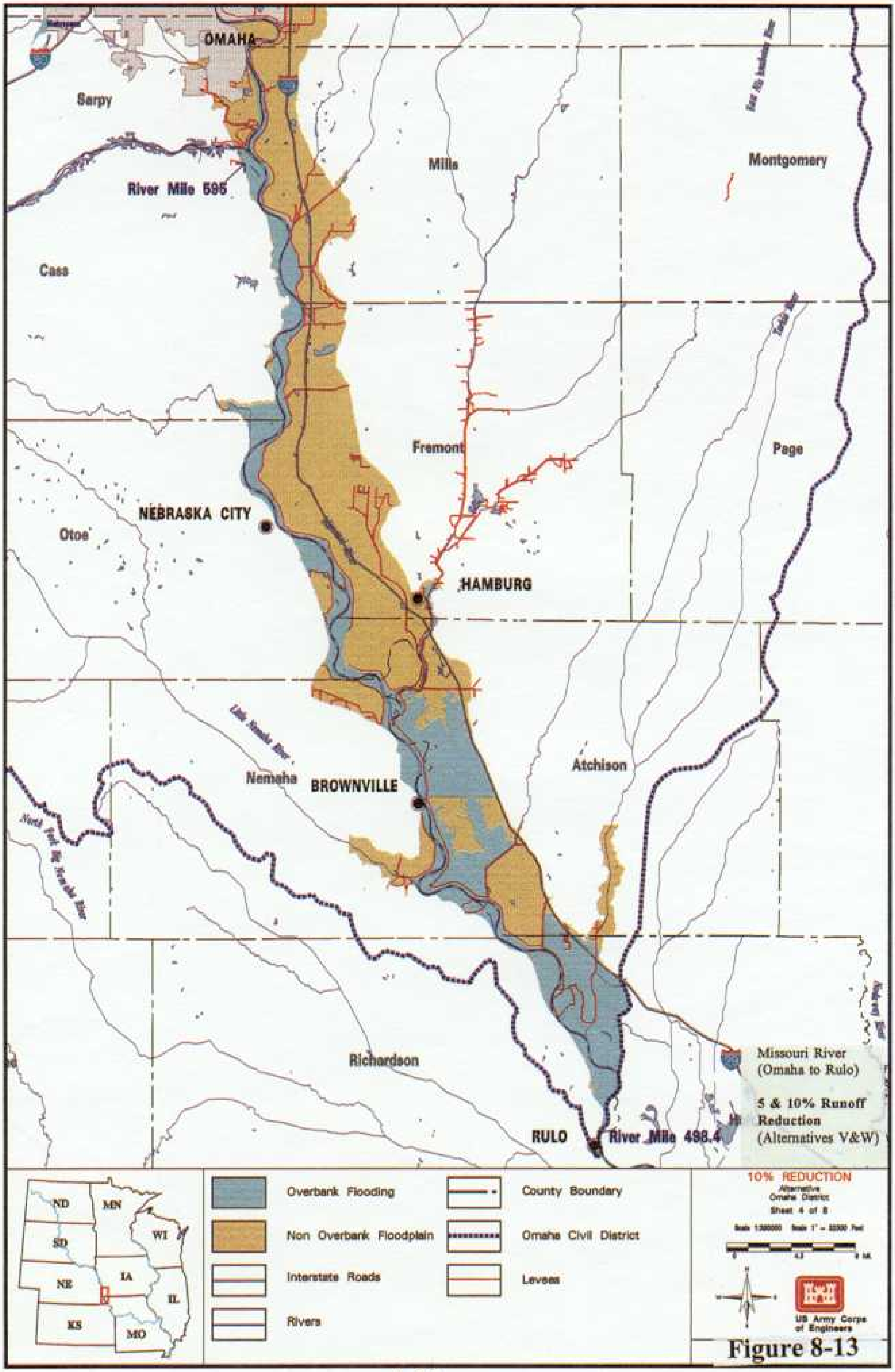
MO
Overbank Flooding
Non Overbank Floodplain
Interstate Roads
Rivers
County Boundary
Omaha Civil District
Levees
FULLY CONFINED CHANNEL
US Army Corps
of Engineers
Figure 8-12



OMAHA
Sarpy
Mills
Montgomery
River Mile 595
Cass
Fremont
Page
NEBRASKA CITY
Otoe
HAMBURG
Nemaha
BROWNVILLE
Atchison
Richardson
RULO
River Mile 498.4
Missouri River
(Omaha to Rulo)
5 & 10% Runoff Reduction
(Alternatives V&W)
Overbank Flooding
Non Overbank Floodplain
Interstate Roads
Rivers
County Boundary
Omaha Civil District
Levees
10% REDUCTION
ND
MN
SD
WI
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IA
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KS
MO
US Army Corps of Engineers

Figure 8-13

Table 8-1
Mississippi River Hydraulic Impact Alternatives
Change in Stage from 1993 Flood
(Unit of Measure is Feet)

MISSISSIPPI RIVER GAGE	RIVER MILE	AGRICULTURAL LEVEES REMOVED		1993 FLOOD CONFINED	25-YEAR LEVEE	NO RESERVOIR	RUNOFF REDUCTION		LEVEES SETBACK
		AGRICULTURAL LOW ROUGHNESS	NATURAL HIGH ROUGHNESS				5 PERCENT	10 PERCENT	
ST PAUL	839.3	N/A	N/A	N/A	N/A	0.0	-0.6	-1.3	N/A
WINONA	725.7	N/A	N/A	N/A	N/A	0.0	-0.5	-1.0	N/A
L&D 10 TW	615.2	N/A	N/A	N/A	N/A	0.0	-0.6	-1.2	N/A
CLINTON	588.7	0.0	0.0	0.0	0.0	0.0	-0.7	-1.4	0.0
DAVENPORT	565.1	-1.6	-0.8	+0.2	-0.2	0:0	-0.7	-1.5	-0.5
MUSCATINE	455.2	-5.9	-3.9	+0.3	-0.6	0.0	-0.7	-1.5	-1.5
BURLINGTON	403.1	-1.7	-0.8	+0.3	-1.1	0.0	-0.9	-1.7	-1.0
QUINCY	327.9	-3.4	+0.4	+3.8	-2.3	+0.3	-0.9	-1.4	-1.2
HANNIBAL	309.9	-5.8	+0.6	+4.2	-3.3	+0.4	-1.0	-1.9	-0.7
L&D 22 TW	301.1	-5.0	-1.0	+3.5	-3.3	+0.3	-0.8	-1.5	-0.6
GRAFTON	218.3	-0.9	+1.4	+5.2	-4.3	+3.3	-0.3	-1.8	-0.8
ST. LOUIS	179.6	-2.7	-0.3	+6.3	-3.3	+3.2	-1.1	-1.2	-1.8
CHESTER	109.9	-7.2	-1.0	+5.8	-3.4	+4.0	-1.2	-1.8	-0.4
CAPE GIRARDEAU	52.0	-0.8	+1.5	+4.1	-2.3	+3.2	-0.6	-1.2	-0.2

Note: Values in this table are approximate and appropriate only for this assessment. A more detailed model is required to accurately estimate the flow capacity of the floodplain. Roughness values for the floodplain were selected to represent variations in land use and provide an upper and lower bound for overbank conveyance. Data on bridges, roads, railroad embankments, and existing vegetation were unavailable for the model. As a result, effective overbank flow area is overstated at some locations. Although further analysis may result in different stages for the without levee conditions, the general trends should remain the same.

Table 8-2
Missouri River Hydraulic Impact Alternatives
Change in Stage from 1993 Flood
(Unit of Measure is Feet)

MISSOURI RIVER GAGE	RIVER MILE	AGRICULTURAL LEVEES REMOVED		1993 FLOOD CONFINED	25-YEAR LEVEE	NO RESERVOIR	RUNOFF REDUCTION		LEVEES SETBACK
		AGRICULTURAL LOW ROUGHNESS	NATURAL HIGH ROUGHNESS				5 PERCENT	10 PERCENT	
OMAHA	615.9	-0.3	+0.1	0.0	0.0	+4.9	-0.7	-1.4	0.0
NEBRASKA CITY	562.6	-4.7	-2.3	0.0	-1.8	+2.5	-0.7	-1.5	-0.4
RULO	498.1	-1.3	+2.0	+7.2	-2.6	-0.1	-0.5	-0.5	+1.0
ST. JOSEPH, MO	448.2	-3.0	-2.9	+1.6	-5.0	+0.4	-0.2	-0.6	+0.4
KANSAS CITY,	366.1	-1.2	-2.9	+2.8	-4.5	+5.1	-1.1	-2.2	-0.5
WAVERLY, MO	293.4	-2.7	-0.7	+6.9	-0.7	+1.2	-0.3	+1.2	+0.7
BOONVILLE, MO	197.1	-0.1	+1.8	+4.1	-0.3	+1.4	-0.5	-0.4	+1.0
HERMANN, MO	97.9	+1.0	+4.6	+6.8	-0.8	+3.6	-0.2	+0.6	+0.6
ST. CHARLES,	28.3	-2.5	+0.9	+2.5	-1.8	+3.8	-0.2	-0.3	-0.6

Note: Values in this table are approximate and appropriate only for this assessment. A more detailed model is required to accurately estimate the flow capacity of the floodplain. Roughness values for the floodplain were selected to represent variations in land use and provide an upper and lower bound for overbank conveyance. Data on bridges, roads, railroad embankments, and existing vegetation were unavailable for the model. As a result, effective overbank flow area is overstated at some locations. Although further analysis may result in different stages for the without levee conditions, the general trends should remain the same.

Table 8-3
Mississippi River Hydraulic Impact Alternatives
Percent Change in Maximum Discharge from 1993 Flood

MISSISSIPPI RIVER GAGE	RIVER MILE	AGRICULTURAL LEVEES REMOVED		1993 FLOOD CONFINED	25-YEAR LEVEE	NO RESERVOIR	RUNOFF REDUCTION		LEVEES SETBACK
		AGRICULTURAL LOW ROUGHNESS	NATURAL HIGH ROUGHNESS				5 PERCENT	10 PERCENT	
ST PAUL	839.3	N/A	N/A	N/A	N/A	N/A	-5%	-10%	N/A
WINONA	725.7	N/A	N/A	N/A	N/A	N/A	-5%	-10%	N/A
L&D 10 TW	615.2	N/A	N/A	N/A	N/A	N/A	-5%	-10%	N/A
CLINTON	588.7	+0.6%	+0.5%	+0.2%	-1.3%	+0%	-4.5%	-9.2%	-0.1%
DAVENPORT	565.1	+1.5%	+1.4%	+1.1%	+0.9%	+0%	-3.7%	-8.7%	+1.0%
MUSCATINE	455.2	+1.3%	+1.0%	+0.6%	-0.4%	+0%	-4.2%	-8.9%	+0.4%
BURLINGTON	403.1	-0.2%	-1.9%	+3.2%	-6.4%	+0%	-4.0%	-9.1%	-0.1%
QUINCY	327.9	+7.5%	+4.9%	+8.3%	+0.7%	+3.1%	-6.9%	-10.9%	-0.4%
HANNIBAL	309.9	+15.4%	+11.5%	+16.3%	-11.9%	+1.3%	-3.5%	-4.1%	+6.6%
L&D 22 TW	301.1	+15.2%	+11.2%	+16.7%	-14.0%	+1.6%	-9.6%	-5.1%	-4.3%
GRAFTON	218.3	-3%	-3%	+22%	-24%	-2%	-8%	-13%	-10%
ST. LOUIS	179.6	+1%	-4%	+19%	-16%	+20%	0%	-8%	-1%
CHESTER	109.9	+8%	+2%	+23%	-12%	+14%	-4%	-7%	0%
CAPE	52.0	+9%	+2%	+24%	-12%	+16%	-4%	-6%	+1%

Note: Values in this table are approximate and appropriate only for this assessment. A more detailed model is required to accurately estimate the flow capacity of the floodplain. Roughness values for the floodplain were selected to represent variations in land use and provide an upper and lower bound for overbank conveyance. Data on bridges, roads, railroad embankments, and existing vegetation were unavailable for the model. As a result, effective overbank flow area is overstated at some locations.

Table 8-4
Missouri River Hydraulic Impact Alternatives
Percent Change in Maximum Discharge from 1993 Flood

		AGRICULTURAL LEVEES REMOVED					RUNOFF REDUCTION		
MISSOURI RIVER GAGE	RIVER MILE	AGRICULTURAL LOW ROUGHNESS	NATURAL HIGH ROUGHNESS	1993 FLOOD CONFINED	25-YEAR LEVEE	NO RESERVOIR	5 PERCENT	10 PERCENT	LEVEES SETBACK
OMAHA	615.9	0.0%	0.0%	0.0%	0.0%	+47.9%	-5.0%	-10.0%	0.0%
NEBRASKA CITY	562.6	-4.8%	-10.9%	+0.1%	-0.8%	+37.8%	-5.5%	-11.4%	+1.1%
RULO	498.1	N/A	N/A	N/A	-13.2%	-2.0%	-8.8%	-8.6%	+36.6%
ST. JOSEPH, MO	448.2	-5.3%	-22.0%	+15.1%	-35.5%	+4.2%	-2.5%	-5.8%	+3.9%
KANSAS CITY,	366.1	-4.1%	-14.2%	+9.4%	-19.0%	+23.5%	-3.8%	-8.3%	-2.5%
WAVERLY, MO	293.4	-3.0%	-11.5%	+8.7%	-1.3%	+14.4%	-4.5%	-5.9%	-2.6%
BOONVILLE, MO	197.1	+2.9%	-4.6%	+12.1%	-13.6%	+15.9%	-5.7%	-4.4%	-0.4%
HERMANN, MO	97.9	+3.5%	-4.7%	+13.5%	-12.1%	+31.3%	-5.4%	-5.6%	+0.3%
ST. CHARLES,	28.3	+3%	-5%	+14%	-14%	+32%	-4%	-8%	+0%

Note: Values in this table are approximate and appropriate only for this assessment. A more detailed model is required to accurately estimate the flow capacity of the floodplain. Roughness values for the floodplain were selected to represent variations in land use and provide an upper and lower bound for overbank conveyance. Data on bridges, roads, railroad embankments, and existing vegetation were unavailable for the model. As a result, effective overbank flow area is overstated at some locations.

Systemic Analysis Results

Examination of the results illustrated several interesting aspects of applying the alternatives on a system-wide basis. Results were examined to compare base and alternative conditions with respect to hydrograph timing, peak flow, peak stage, levee overtopping and stages within levee cells, and flood duration. When comparing alternatives, all parameters such as peak flow, stage, and levee cell stage must be examined throughout the entire reach to completely evaluate the effects of each alternative. Specific comments regarding the effects of modeled alternatives are as follows:

River Stage. In general, the largest stage reduction was achieved with the levee removal alternative for the low roughness condition. Compared at most tabulated locations, both the levee removal alternative and the 25-year notch alternative provide stage decreases which exceed the decrease computed for the runoff reduction alternatives. The confined levee alternative produced the highest stage increase.

Stage reduction is not uniform throughout the system for any of the alternatives. Fluctuations in computed stages are the result of systemically combining the impacts of inflow hydrographs with changes in the time and number of levee breaches which occurred. Examination of stage, discharge, and the time at which levee breaches occur at a location often explains why the computed stage appears to be inconsistent. One scenario which describes how stage fluctuations occur is as follows:

1) The alternative reduces discharge and/or lowers stage at point A.
2) The levee at point A does not breach or breaches at a later time (compared to base condition).
3) Additional flow continues downstream since the levee cell no longer stores water.
4) Stage and/or discharge at point B increase when the additional flow from point A is combined with the timing of other inflows to point B.

River Discharge. The largest reduction in discharge at most locations was computed for the levee removal alternative with natural forested floodplains. The levee confinement alternative produced the highest increase in discharge. Compared at most tabulated locations, both the levee removal alternative and the 25-year notch alternative provide discharge decreases which exceed the decrease computed for the runoff reduction alternatives. An alternative which produced a discharge decrease may often correspond with an increase in stage due to changes in roughness, hydrograph timing, or levee breaching. Some alternatives also increase discharge which then has a negative impact at further downstream locations.

Hydrograph Timing. Many of the alternatives dramatically affected the time at which peak stages and discharges occurred. For example, both the levee removal and 25-year levee height alternatives shifted the time at which peaks occurred by 2 to 4 days at many locations. Since the timing of inflow from the major tributaries does not change, some alternatives produced unexpected stage increases when the timing shift caused by the alternative happened to coincide with the tributary peak time of inflow. An example of how the 25-year levee alternative altered the time at which peak stages occurred at Quincy, Illinois, is shown on Figure 8-14 .

Levee Cells. A negative aspect of some alternatives is that either the flooded area or the peak stage within the levee cell increased. Changing storage volume within levee cells also affects downstream flows and stages.

Noted Hydraulic Impacts. Several additional impacts which were noted from examination of results are as follows:

The performed analysis illustrates that no

EXAMPLE OF TIMING SHIFT CAUSED BY ALTERNATIVE

MISSOURI RIVER AT NEBRASKA CITY, NEBRASKA - RM 562.6

1993 COMPUTED, 25-YEAR LEVEES AND LEVEES REMOVED

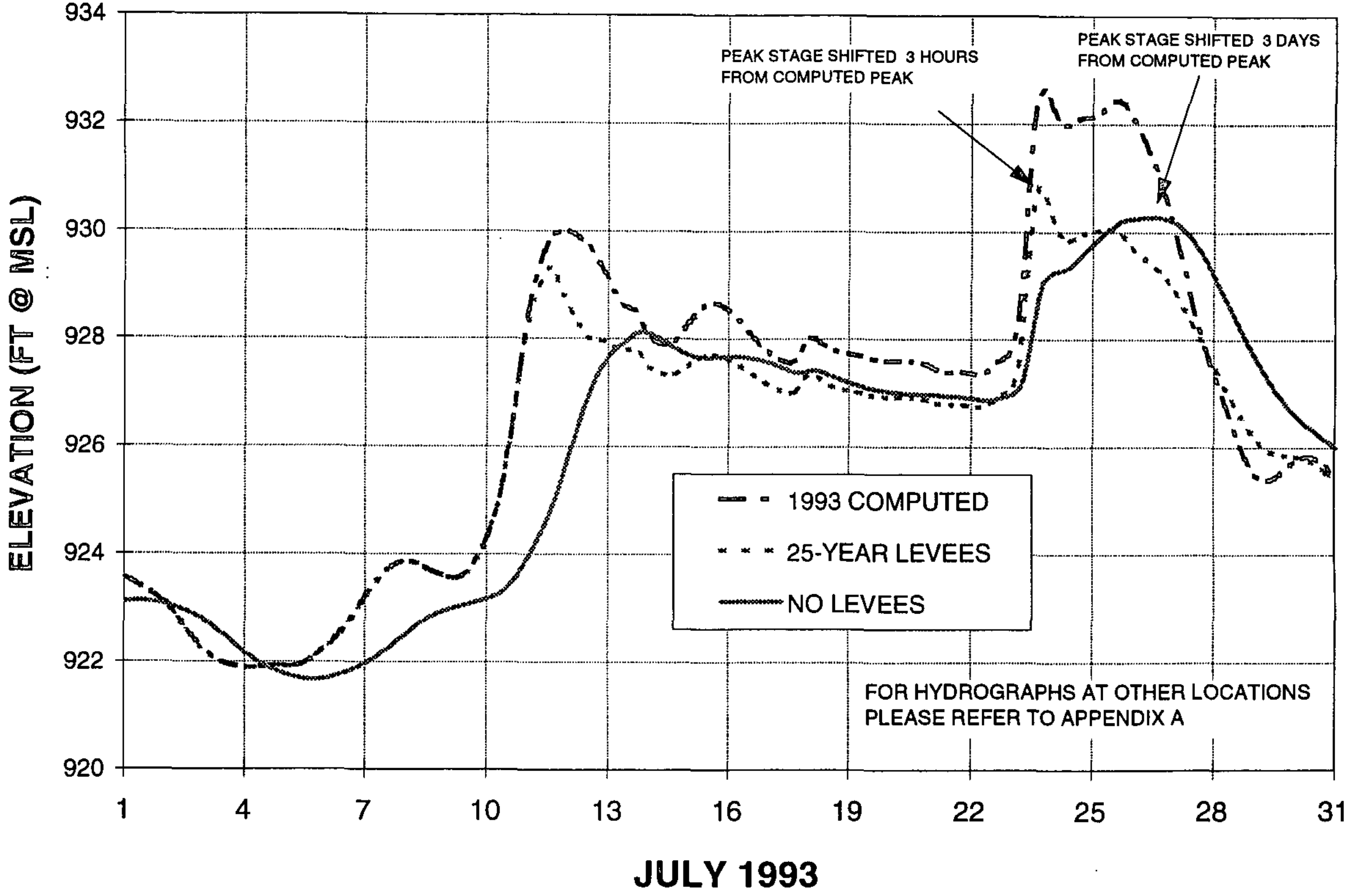

Figure 8-14

single alternative provides beneficial results throughout the system. Applying a single policy system-wide will cause undesirable consequences at some locations. Examination of many factors such as computed peak stages, discharges, and flooded areas and depth is necessary to evaluate how an alternative affects performance of the flood control system as a whole.

Several of the alternatives altered hydrograph timing. A complete evaluation is required prior to implementing any alternative to investigate performance for a variety of events with different inflow characteristics. The model illustrated that alternatives which provide a local beneficial impact by reducing flows and stages may cause downstream consequences when the timing of levee overtopping and hydrograph peaks is altered and peak stages are increased. Alternatives which altered timing often produced stage increases at unexpected locations.

Results of the levee removal alternative illustrated that all model results which determine a stage and discharge reduction are extremely dependent upon assumptions regarding floodplain use and flow roughness. A change in channel or overbank roughness from the conditions assumed may significantly alter computed results.

The runoff reduction, levee removal, and 25-year levee height alternatives all reduced computed peak flow and stage at many locations. Reductions for the levee removal and 25-year levee height alternatives were possible as the result of flooding additional agricultural land. Runoff reductions would also require the additional inundation of a significant land area to store 5 or 10 percent of the runoff volume.

Simulation of the 1993 event and the various alternatives illustrated several positive and negative aspects of floodplain management. The FPMA study focused on the 1993 event only. Other events may generate different conclusions. Applying what appears to be good floodplain strategy within a limited area can have undesirable effects at other locations within the river system. Employing an unsteady flow model to simulate the 1993 event and alternatives illustrated that the entire system must be evaluated as a whole and not in individual segments. Several of the alternatives examined showed potential for decreasing damage associated with an event similar to 1993. However, the cost of implementing these alternatives must also be considered.

Extrapolating conclusions obtained from analysis of 1993 event modeling may be erroneous with respect to other events. For example, determining whether any individual levee cell will overtop varies for each alternative and flood event. An individual cell may or may not overtop depending upon the river flow, tributary inflow, and levee overtopping either upstream or downstream of the individual cell. Levee overtopping and breaching parameters also vary including time of overtopping or breaching, computed flow, and ponding depth and duration within the cell.

Study results proved that a system-wide hydraulic analysis is required to properly evaluate alternative projects rather than looking at each independently. Basin-wide planning is required to completely evaluate effects of proposed alternatives along the Mississippi and Missouri Rivers. Future levee and floodplain development must be evaluated on a system-wide basis employing accurate modeling techniques.

EXAMINATION OF UPLAND RETENTION-/WATERSHED MEASURES

Upland retention and watershed measures directly influence the volume and peak runoff generated from rainfall events. The performed UNET model analysis evaluated the effect of upland retention and watershed measures on a system-wide basis. The UNET model employed a change in the inflow hydrographs to model 5 and 10 percent runoff reduction alternatives and the without Federal reservoir alternative. The following sections provide additional evaluation of upland measures and further explain the basis for the inflow hydrographs which the UNET model used.

Background: 5 and 10 Percent Flood Runoff Reduction

The defining of runoff relationships through rainfall amount, rainfall intensity, timing of a series of storms, topography, land use, antecedent conditions, drainage network, and consideration of existing upland and valley storage is very complex. It can be the subject of considerable difference of opinion. Unless evaluations are done using a detailed, systematic process, with several calibrations during the process, the results cannot be defended based on scientific procedures. The use of different hydrology runoff models to evaluate various combinations of these runoff relationships occurs throughout the basin, but none evaluate all of the processes over the entire watershed affected by the 1993 flood.

It was determined very early in the assessment process that time and funds were not available to perform comprehensive deterministic hydrologic studies on the entire area affected by flooding in 1993. The approach used in the assessment was to use the available information developed for the Scientific Assessment and Strategy Team (SAST) report and any additional information readily available from other sources such as the Corps of Engineers (COE), Natural Resources Conservation Service (NRCS), and U.S. Fish and Wildlife Service (FWS). This information would help define physical relationships between runoff volume and the structural and nonstructural measures typically used to reduce runoff volume. Because of the tremendous volume involved in the 1993 flood event, it was determined at meetings attended by other State and Federal agencies that the volume reductions on tributary hydrographs should not exceed 10 percent of the recorded 1993 runoff.

The volume of runoff is the most critical and controlling factor for defining flooding in the floodplains of the Mississippi and Missouri Rivers as the contributing area to the flood prone area becomes large. The runoff hydrograph shape is sensitive to upland retention measures in the upland flood prone areas. However, as these upland hydrographs are combined with other tributaries and travel downstream, the shape of the hydrograph becomes less sensitive to individual upland retention measures. Since this assessment concentrates on the flood prone areas of the larger downstream floodplains, the evaluation of the impacts of various upland retention measures on local hydrograph distribution was determined not to be critical. Therefore, impacts of runoff reduction measures addressed in this assessment will assume that uniform volume reductions of tributary hydrographs can be applied without significantly affecting the credibility of the floodplain sensitivity analysis. Appendix A provides additional supporting information on the volume reduction measures evaluated.

Methodology: 5 and 10 Percent Reductions

The systemic UNET analysis employed runoff reductions of 5 and 10 percent to evaluate the effect of reduced runoff on computed results. An analysis was conducted to determine a reasonable value for the maximum runoff reduction which could be attained. The 5 and 10 percent volume reductions are used to test the sensitivity of the floodplain water surface profiles to changes in tributary hydrograph volumes for the

1993 flood. The reductions are intended to represent changes in upland watershed land use through either structural or nonstructural measures. Since the measures were to be weighed against 1993 flood conditions, the volume reductions and measures assumed had to account for the extreme antecedent conditions that existed in these watersheds during the critical months of June through July. The tremendous volumes of runoff experienced throughout the basin when multiplied by 5 or 10 percent reduction factors result in very large storage or retention requirements in some watersheds. These watersheds would require a combination of both structural and nonstructural measures to achieve these volume reductions for the 1993 flood.

The nonstructural measures or land treatments considered included changes in wetland storage, changes in depressional hydric soils drainage patterns, maximizing infiltration through use of conservation practices and cropland conversion. Structural measures would include the traditional Soil Conservation Service (SCS) small (Public Law 566) watershed structures and larger flood storage structures where necessary. The time available to conduct the assessment did not permit a detailed analysis of land use for each sub-watershed. This would require comprehensive deterministic hydrologic models to measure all the physical processes related to these changes. Models exist which represent small portions of the basin, but not to the extent that they would provide appropriate coverage to perform detailed, comprehensive analysis on this very diverse landscape. However, data provided in the SAST report and existing COE, NRCS and other Federal agency data provide a level of understanding of these physical features and processes such that estimates on how land use changes will affect volume relationships can be developed to the level of detail commensurate with this assessment's objective.

The tributary volume adjustments used for the floodplain sensitivity analysis were also based on results from case studies conducted by the SAST team. These case studies evaluated the effects of combinations of land use changes on four selected watersheds which represent four distinct landforms in the upper Mississippi River Basin. The four landforms included a steep basin, a low relief pothole basin, a low relief basin with well-defined drainage, and a relatively high relief basin that has been drained for agriculture. The studies were not conducted using the same hydrologic model, but general trends were identifiable, and relative differences could be noted from the studies. These studies indicated that reductions in flood peaks from upland land treatments can be influenced by many factors. The floodplain geomorphology, hydrologic characteristics, antecedent conditions and precipitation distributions are some of the factors. The studies also indicate a trend toward decreasing influence on flood peaks as precipitation or flood recurrence interval increases. Where land use changes may reduce flood peaks by between 25 and 50 percent for a flood with a return period of 2 to 5 years, the same changes may reduce peaks by only 10 percent or less for floods with return periods of 100 years or greater. Appendix A offers additional discussion and details on the analysis conducted by SAST.

In addition to the SAST case studies, land resource information was developed to further support the runoff reduction measures. This information was provided through the 1992 Natural Resource Inventory (NRI) and the cooperation of the Natural Resources Conservation Service (NRCS) Midwest National Technical Center, Lincoln, Nebraska. The NRI defines land use by major use categories and provides this information for each major tributary in the Mississippi and Missouri River Basins. This data can be used to estimate the upland land use and soils characteristics and how changes in land use may affect runoff volume. In addition to the NRI data, the NRCS STATSGO database was used to compile additional pertinent information related to soils characteristics throughout the basin. Included in this data is an inventory of hydric soils which indicates where in the basin the greatest percentages of these soils exist. The data does not, however, characterize the hydric soils by wetland status. Large percentages of these hydric soils are currently being used for agricultural purposes throughout the basin. Figure 8-15 shows the percent hydric soils within the upper and middle Mississippi River and lower Missouri River basins.

Wetland restoration has proven to be an effective flood reduction measure in the upper watershed areas where the localized effects are most pronounced. The SAST case studies indicate that flood peaks can be reduced significantly for fairly frequent flood events. However, wetland restoration measures would have had drastically reduced effects on flood volumes under the antecedent conditions and the extreme flood conditions that existed throughout most of the watershed in 1993. It is questionable whether restoration of drained depressional areas would contribute to flood reduction under these extreme conditions. It can be argued that these drained depressions actually provide greater flood reduction benefits by preserving the depressional storage for the most extreme rainfall events through drainage of antecedent events. The drainage of wetlands is a very complex hydrologic issue with broad social, political, economic and environmental impacts. This assessment will address the restoration of wetlands as one of a combination of the upland measures used to achieve the 5 and 10 percent volume adjustments in the upper watersheds. Appendix A provides additional details and inventories of the current wetlands status for the entire upper Mississippi River Basin and will indicate where in the basin wetland restoration would have had the most influence on the 1993 flood.

In summary, the volume reductions assumed for the floodplain sensitivity analysis are 5 and 10 percent of the 1993 runoff volume from all tributaries of the Mississippi River above Cairo, Illinois, and below Sioux City, Iowa, on the Missouri River. The adjustments are not based on specific flood reduction measures or combinations of measures for each tributary. Instead, it is assumed that there is a combination of both nonstructural and structural changes that could achieve these reductions. It is also assumed that the 10 percent volume reduction is an upper bound on what is reasonably achievable under the extreme antecedent conditions and flood conditions that existed throughout most of the watershed in 1993.

Upland Flood Control Measures

Control of runoff in the upland watershed is accomplished through both structural and nonstructural measures. These measures include land treatments that affect the soil's infiltration rate, the soil moisture retention capacity and protection or restoration of natural floodwater storage areas. Wetlands, or construction practices like terraces, farm ponds, erosion control structures or flood control reservoirs, all have capacity to store excess runoff. The impacts of existing land use and upland treatments on the 1993 flood were estimated using information included in the SAST report along with data from the NRCS, COE, National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), and USGS. The existing Federal reservoirs located in the upland areas stored over 25 million acre-feet of water during the flood event. It is estimated that existing farm ponds, erosion control structures and flood control reservoirs constructed with U.S. Department of Agriculture (USDA) assistance stored over 2 million acre-feet of water during the flood.

Several alternatives were considered to test the sensitivity of different types of upstream flood control measures. The "Existing Condition" alternative identifies the base condition which treats all land use and upland storage in Federal reservoirs as they existed in 1993. The "Without Federal Reservoirs" alternative is used to identify the effects the 1993 storage in these reservoirs had on reduced flood stages in the

Percent Hydric Soils

by HUC-8 Units

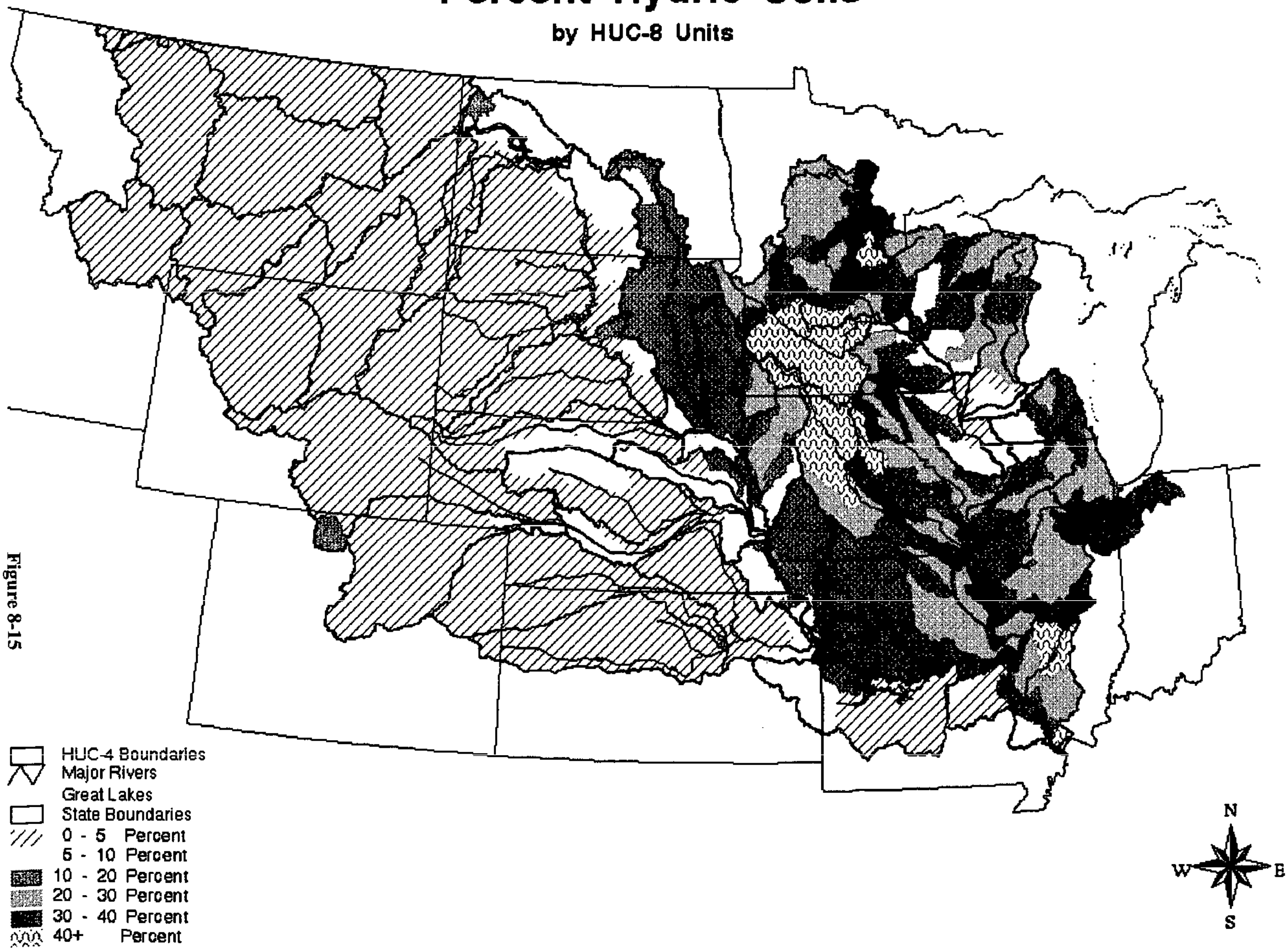

Figure 8-15

downstream floodplain. The "With Revised Reservoir Operations" alternative reviews existing operating plans to determine if adjustments to these plans would have further reduced flooding in the floodplain. The "Runoff Reductions of 5 and 10 Percent" alternative looked at assumed volume reductions to the tributary hydrographs through additional upland land use changes or storage measures. These reductions were based on very general information at this time, and additional detailed evaluations will be needed to determine optimum combinations of nonstructural and structural measures required. These alternatives are summarized below and also discussed in greater detail in the hydraulics and hydrology appendix.

Existing Conditions. The existing conditions scenario evaluates all land use conditions and reservoir operations as they actually existed in the 1993 flood. Conditions conducive to producing extreme runoff existed with antecedent soil moisture in 70 to 90 percent of soil capacity throughout most of the basin, and precipitation patterns were well above normal over most of the basin. These antecedent conditions reduced the ability of the upland features such as wetlands, flood storage reservoirs and depressional areas to store runoff. The extreme soil moisture contents significantly reduced the soil's ability to store additional water. Also, the extremely wet, cool conditions had drastically inhibited spring planting in many areas, resulting in little vegetation in the fields of this heavily farmed region. This further exacerbated the flood conditions, as it reduced the soil moisture holding capacity and left little vegetation for evapotranspiration. The soil recovery rates (the ability to percolate water to the groundwater table and remove topsoil moisture through evapotranspiration) were also reduced due to the persistent wet cycle and lack of vegetation.

Rainfall events described in Chapter 1 were intense storms which occurred over short periods of time on soils near saturation. These storm durations range from several hours to 1 to 2 days, with rainfall intensities exceeding 1 inch per hour during portions of these storms. The soils over most of the basin had reduced infiltration rates that were well below 0.1 to 0.15 inch per hour that could normally be expected during this time of year. Therefore, rainfall exceeding these reduced infiltration capabilities went into direct runoff. The natural ability of the uplands to attenuate the runoff through depressional and wetland storage has been depleted through the years by agricultural and urban drainage. Also, the spring antecedent conditions and the succession of storms which pelted the Midwest would have further reduced storage in these natural buffers. The combination of these extreme conditions led to excessive runoff throughout the basin. The Federal reservoirs throughout the basin played a significant role in reducing this runoff and lowering stages in many ares hit hardest by the 1993 flood.

The SAST report included information on the impacts of the many upland treatment programs administered by the USDA and how these programs may have contributed to reduced flood volumes in 1993. Those programs include the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP) and erosion control programs such as terracing and residue management. The Natural Resources Conservation Service estimates that the combined effects of these programs within the State of Iowa amounted to reducing runoff volume by about 700,000 acre-feet. These upland reduction measures affect each rainfall event that occurs to some extent as both storage of runoff and soil infiltration are affected. While the estimated impact on the runoff volume is considerable, it is not large when compared to the total runoff from 1 June to 30 August on the Des Moines River which alone was almost 10 million acre-feet. In contrast, the total flood storage available in Corps dams on the Iowa and Des Moines Rivers is about 2.5 million acre-feet. It is estimated that USDA assisted farm ponds, erosion control structures and Public Law 566 structures in Iowa provided an additional 200,000 acre-feet of temporary flood storage that was used several times during the flood event. Further discussion of the influence of upland land use on the 1993 flood is available in the hydraulics and hydrology appendix of this report.

With Federal Reservoirs

The severe flooding in 1993 resulted in damaging stages throughout the Mississippi and Missouri River Basins. These stages would have been higher in many locations if the system of flood control reservoirs had not been in place in many of the tributaries to the main stem rivers. The available flood control storage on the Mississippi River above St. Louis is about 5.8 million acre-feet. The total storage used during the 1993 flood from April 1 to the maximum reservoir levels at the respective sites on the Mississippi River was about 4.3 million acre-feet (MAF). The available storage on the Missouri River above St. Louis includes 13.4 MAF of flood control storage in tributary reservoirs and about 73.5 MAF of storage in the six main stem reservoirs. The main stem reservoir storage is divided into four storage zones: 4.7 MAF of exclusive flood control storage, 11.7 MAF of annual flood control and multiple use storage, 39 MAF of *carry-over multi-use storage* (a portion of which was available at the start of the 1993 flood) and 18.1 MAF of permanent storage. The total storage used during the 1993 flood from April 1 to the maximum reservoir levels in the six Missouri River main stem reservoirs above Sioux City, Iowa, was about 10.3 MAF. The tributary reservoirs stored approximately 10.5 MAF during this same period of the flooding.

The main stem reservoirs had rebounded slightly from record low storage of 40.8 MAF in January 1991, and storage levels leading into the 1993 flood season were at about 43 MAF. The available storage in the main stem reservoirs leading into the 1993 flood was about 30 MAF. Therefore, the main stem reservoirs could have stored more water had it been required, as only about 10.3 MAF of the available storage was used during the flood. In addition to the major Corps of Engineers and Bureau of Reclamation projects included in the above numbers, there are numerous *Department of Agriculture* (NRCS), State and private impoundments which account for an additional 2+ million acre-feet of storage throughout the basins. The volume of the total flood control storage used above St. Louis during the period June to August equals nearly 22 percent of the total hydrograph volume that passed St. Louis during that same period. The effects of the major reservoirs are outlined below, and Appendix A provides additional details on storage by tributary. The basins with the most significant contributions in 1993 to flood control storage are listed in Table 8-5 .

TABLE 8-5
SELECT RESERVOIR EFFECTS
1993 Flood

FEDERAL FLOOD CONTROL STORAGE [1] (1,000 AC-FT)			
BASIN NAME	TOTAL RESERVOIR FLOOD CONTROL STORAGE	MAXIMUM CHANGE IN RESERVOIR STORAGE (1993) (1)	PERCENT OF FLOOD CONTROL STORAGE USED
IOWA RIVER	434	558	129%
DES MOINES R	2,070	2,644	128%
WYACONDA/SALT	884	627	71%
KASKASKIA/MERAMEC	1,693	191	11%
JAMES R	329.2	117	36%
SMOKEY HILL R	1,312.7	845.4	64%
KANSAS R	4,859.4	4,436	90%
CHARITON/LT.CHARIT	376.4	393.6	105%
OSAGE R	5,657.1	4,207	74%
MISSOURI MAINS: [2]			
FORT PECK	2,657	2,085	0%
GARRISON	4,250	4,453	0%
OAHE	2,390	3,426	<10%

(1) Data from COE 1993 Post Flood Reports.
Storage during the 1993 flood includes total change in storage between the initial starting elevations and the maximum reservoir elevations experienced. Percentages greater than 100 percent indicate that additional storage was used either due to low reservoir levels leading into 1993 or the maximum reservoir elevations exceeded flood pool and surcharge storage was used. Many of the reservoirs in the system stored and released water several times during the span of the flood. These cumulative effects are not reflected in this table.
(2) Almost all storage in the Missouri River main stem reservoirs was in the multi-purpose storage areas. Only Oahe rose slightly into the annual flood control and multi-purpose zone.

Tables 8-6 and 8-7 show the effects lake and reservoir storage had on reduced discharges and stages on the Kansas and Missouri Rivers during the 1993 flood. Discharges on the Kansas

River were reduced by 56 percent at Fort Riley and by 35 percent at the Desoto gage near the confluence with the Missouri River. Reservoir operations in the headwaters of the Kansas River Basin reduced discharges by up to 80 percent. This indicates that, as contributing drainage area increases, the effects of upstream storage become less pronounced. This is due in part to the fact that the amount of area uncontrolled by the reservoirs increases as the basin size and number of contributing streams increase. The reservoir storage influence on discharges on the Missouri River main stem accounted for a 27 percent reduction in discharge at St. Joseph, and farther downstream, the reduction in discharge at Hermann was about 12 percent.

Table 8-6
Kansas River - 1993 Flood
Actual and Unregulated Stages and Discharges

Stream Gage			Actual			Unregulated		Stage Reduction by Federal Reservoirs (ft.)
Place	River Mile	Flood Stage (ft.)	Date	Discharge (cfs)	Stage (ft.)	Discharge (cfs)	Stage (ft.)	
Fort Riley	168.9	21.0	7/26/93	87,600	27.9	200,000	35.0	7.1
Wamego	126.9	19.0	7/26/93	199,000	27.3	258,000	28.9	1.6
Topeka	83.1	26.0	7/25/93	170,000	34.9	260,000	37.1	2.2
Lecompton	63.8	17.0	7/27/93	190,000	24.7	282,000	26.9	2.3
Desoto	31.0	24.0	7/27/93	170,000	26.9	266,000	31.4	4.5

Data from 1993 Post Flood Report, Appendix E.

Kansas River. The operation of the 18 Corps of Engineers and Bureau of Reclamation lake and reservoir projects in the Kansas River Basin for flood control purposes resulted in significant reductions in the depth of flooding that occurred in July-August 1993 on the Kansas River, Missouri River, and those tributary streams of the Kansas River below each project. Table 8-6 contains information on stage reductions at five pertinent locations on the Kansas River. Reduction in stage varies from 1.6 feet at Wamego to 7.1 feet at Fort Riley. In the lower reach at Desoto, Kansas, near the Kansas City metropolitan area, the flooding depth was reduced 4.5 feet.

Table 8-7
Missouri River - 1993 Flood
Actual and Unregulated Stages and Discharges

Stream Gage			Actual			Unregulated		Stage Reduction by Federal Reservoirs (ft.)
Place	**River Mile**	**Flood Stage (ft.)**	**Date**	**Discharge (cfs)**	**Stage (ft.)**	**Discharge (cfs)**	**Stage (ft.)**	
St. Joseph	448.2	17.0	7/26/93	335,000	32.6	461,000	33.0	0.4
Kansas City	366.1	32.0	7/27/93	541,000	48.9	713,000	54.0	5.1
Waverly	293.4	20.0	7/27/93	633,000	31.2	700,000	32.4	1.2
Boonville	197.1	21.0	7/29/93	755,000	37.1	820,000	38.5	1.4
Hermann	97.9	21.0	7/31/93	750,000	36.2	852,000	39.8	3.6

Data from 1993 Post Flood Report, Appendix E. Revised stages based on FPMA UNET modeling.

Missouri River. Table 8-7 presents information on stage reductions at five pertinent locations on the lower Missouri River below Rulo, Nebraska. These stage reductions reflect the flood control effects of the previously mentioned projects in the Kansas River basin; an additional 11 projects in the lower Missouri River Basin [Metro Kansas City area (3), Chariton River and Little Chariton River Basin (2), and Osage River Basin (6)]; as well as the Missouri River main stem and tributary reservoir system upstream of Rulo. Reduction in stage varied from 5.1 feet at Kansas City to 3.6 feet at Hermann. The 0.4-foot stage reduction at St. Joseph was due entirely to the reservoir system upstream of Rulo. The six projects in the Osage River basin were operated to reduce flood stages at Hermann and also to lower stages on the Mississippi River at St. Louis.

Des Moines River. Reservoir flood storage is not designed to control all flood events. When flood volumes exceed the designed flood storage volumes of reservoirs, there will be discharge through a supplemental spillway which is usually uncontrolled. In many areas during the 1993 flood, reservoir flood control capabilities were exceeded due to extreme antecedent floods or storms which exceeded the design capacity. This resulted in many of these projects making uncontrolled releases from the reservoirs which are controlled by a surcharge relationship for the emergency spillway. The Des Moines River Basin projects are an example of inflow exceeding the flood control capabilities. The available flood storage in Saylorville and Red Rock reservoirs was only about 5 percent of the total runoff volume during peak flooding on the Des Moines River in June and July. However, the projects were still capable of reducing the discharge by 10 to 20 percent and resultant stages downstream by 1 to 3 feet. Figure 8-16 displays the hydrographs for the regulated and unregulated discharges at Keosauqua, Iowa. Regulation managed to reduce the maximum discharge at Keosauqua to 108,000 cfs as opposed to an unregulated discharge of 132,000 cfs.

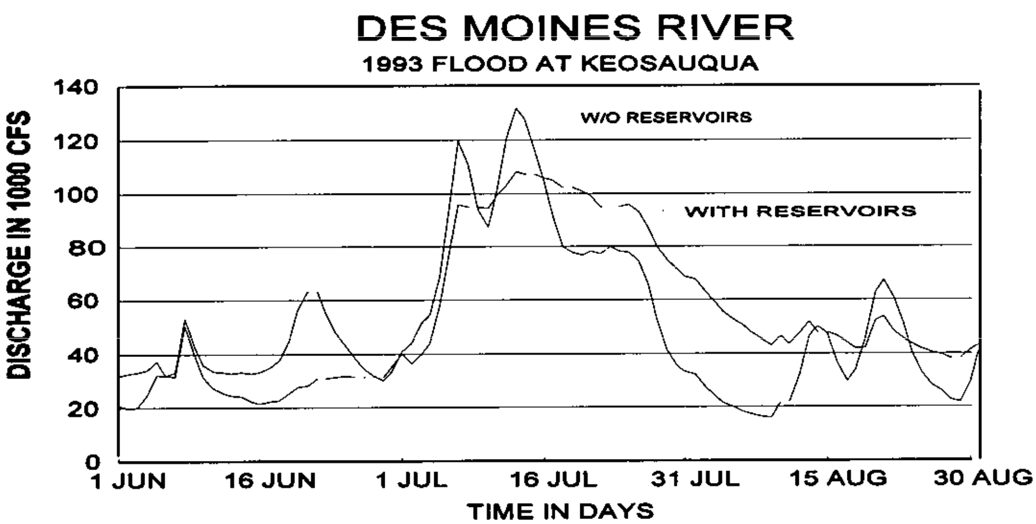

Figure 8-16

Without Federal Reservoirs

The UNET analysis of the 1993 flood event without the Federal reservoir storage was accomplished by determining the discharge hydrograph at each site without the storage effects of the reservoir. These unregulated hydrographs were then routed downstream to determine the effects on peak discharges and stages at critical locations. The hydrographs were routed to the Missouri and Mississippi River main stems from the upstream tributaries using hydrologic routing, and the UNET model was used to route the hydrographs through the floodplains to determine resultant water surface profiles. The flood storage in Federal reservoirs had significant impacts on flood stages during the 1993 flood on the Mississippi River from Grafton to Cape Girardeau and on the Missouri River from Gavins Point Dam to the mouth at St. Louis. Flood stages in these reaches would have been several feet higher if the Federal reservoir system had not existed.

Missouri River. The farthest downstream of the six main stem dams on the Missouri River Federal reservoirs is Gavins Point Dam at RM 811.1. The Missouri River Division Reservoir Control Center (RCC) annually computes the without reservoir hydrograph at Gavins Point Dam based on routed upstream inflows. The without reservoir hydrograph computed by RCC at Gavins Point Dam did not contain any large peak flows during the 1993 event. Discharge generally varied from 60,000 to 90,000 cfs for a 3-month period. Essentially, the without reservoir hydrograph is equivalent to adding substantial base flow to the Missouri River for the 1993 event. Discharges for the Kansas River at Desoto without reservoir holdouts would have been approximately 266,000 cfs as opposed to 170,000 cfs for the regulated condition. Downstream at Hermann, the unregulated discharge would have approached 850,000 cfs as opposed to 750,000 cfs for the regulated condition.

Mississippi River. Elimination of all Federal flood control storage in the entire upper

Mississippi River system would result in an increase in stage at St. Louis of about 3.2 feet. Tables 8-1 and 8-2 show the increased stages that would have occurred without Federal reservoir storage at various stations along the Mississippi and Missouri Rivers. The stage increases are less than 0.5 foot above Lock and Dam 22 on the Mississippi River, but increase to 3.3 feet when the effects of reservoir storage on the Salt and Illinois Rivers are added to the discharges. Stage increases on the Missouri River with reservoir holdouts added in vary from near zero to over 5 feet in the reach from Omaha to St. Charles, depending on effects of the agricultural levees and the timing of inflow.

CASE STUDIES

With completion of the systemic modeling on the Mississippi and Missouri Rivers network, a limited number of case studies were completed to allow analysis of potential impacts for specified reaches in each District and not as part of a systemic study. Each Corps District performed several case studies that included analyses pertaining to reservoir operation and antecedent conditions, levee height and location changes, and interior drainage behind the existing levee systems. The case studies are summarized in the following sections.

RESERVOIRS

Many factors affect the operation of flood control reservoirs during times of flooding. These include revised reservoir releases, distribution and timing of the runoff, storage availability in the reservoirs, downstream flooding conditions and constraints, and operation requirements as set in the water control manuals. The case studies related to reservoirs include determining what the impact on the 1993 flood event would have been, a review of reservoir operation during the 1993 flooding, the impact of additional reservoirs in the Meramec River basin and if reservoir antecedent conditions had been near normal or wet instead of below normal due to a 6-year drought.

Case Study - Revised Reservoir Operation

Reservoir operating plans are designed to equitably serve all the project's intended and authorized purposes. These operating plans are usually keyed to specific benefits which in many cases are local in nature. These optimizations are based on either historic or synthetic flood simulations or on some downstream control point to determine the optimum operating conditions which maximize both upstream and downstream benefits. Also, releases are made based on known hydrologic conditions or forecasts. In the case of the 1993 flood, the downstream hydrologic conditions were a moving target for reservoir operators. Critical rainfall events downstream of these projects occurred after upstream forecasts were made. In some cases, upstream reservoir releases were made several days before significant rainfall events downstream further exacerbated conditions at key downstream damage locations. In most cases, revised operating plans would only benefit had there been foresight of the conditions that changed downstream after releases were made days or in some cases weeks earlier. Table 8-5 displays the storage characteristics of some of the basins with the most significant reservoir influences and indicates the amount and percent of flood storage used. The table indicates that storage effects varied throughout the basin and not all flood control storage was required to meet downstream flood control commitments.

The analysis of reservoir operation plans is complex, with multiple uses and interests competing for water benefits. Revising operating plans to better optimize the flood storage benefits for the 1993 flood could provide slight reductions in local flooding below the reservoirs, but only for the 1993 hydrograph shape and volume. Detailed analysis of revised operation of some reservoirs for the 1993 flood could reveal that some operating plans could be improved based on lessons learned. However, this process is lengthy and beyond the scope of this assessment.

Case Study - Reservoir Operation, St. Louis District

After the 1993 flood, an evaluation of the operation of the Rock Island and St. Louis District flood control reservoirs was performed. St. Louis District has five reservoirs, but two of them were excluded from the case study and the other three were found to have been operated in a superior manner.

Lake Wappapello on the St. Francis River had no impact on the Mississippi River flooding during 1993. The St. Francis River confluence with the Mississippi River is near Memphis, Tennessee, which was south of the major flooding on the Mississippi River during 1993. A detailed study of Lake Wappapello was not conducted. Rend Lake is located on the Big Muddy River. Its confluence with the Mississippi River was within the area of major flooding in 1993. However, Rend Lake's outflow is through an uncontrolled spillway, and no reservoir operation is performed.

The Kaskaskia River has two reservoirs that provided a great deal of flood protection during the flood of 1993. The Kaskaskia River's confluence with the Mississippi River is approximately at Chester, Illinois, which was affected by the 1993 flood. Lake Shelbyville and Carlyle Lake operate as a system. Except for backwater from the Mississippi River, the Kaskaskia River experienced no flood damage during the 1993 flood. The discharge from these two reservoirs did **not** add to the crests or prolong the duration of the 1993 flood. In fact, every crest of the Mississippi River in 1993 was reduced by the operation of these two projects. The two Kaskaskia reservoirs operated as designed during the 1993 flood.

Mark Twain Lake on the Salt River was an exceptionally successful case. Extremely close coordination with the downstream landowners association (LSRBA) played a critical role. Close coordination and frequent special internal river forecasts allowed the water control manager to release water at the optimum time and provide the maximum possible flood control benefits for both the Salt River and Mississippi River basins. The Mark Twain flood control pool was filled and emptied 3.5 times during 1993 with not a single damaging release. The excellent reservoir operation of Mark Twain Lake did not aggravate flooding on the Salt River and Mississippi River.

In conclusion, based on post-flood analysis, the St. Louis District's three reservoir projects did not aggravate flooding during the 1993 flood, and no changes are needed to the reservoir operation procedure as required in the water control manuals.

In the Rock Island District, all three major flood control reservoirs, Saylorville, Red Rock, and Coralville, were operated beyond full flood control capacity during the 1993 flood event. Higher authority granted deviation from approved regulation plans, allowing lower than prescribed release rates in order to aid floodfighting efforts in downstream communities and to minimize impacts to affected critical facilities. As a result, Saylorville and Red Rock reservoirs on the Des Moines River rose to 2 to 3 feet above designated full flood control pool levels. Coralville reservoir rose to nearly 5 feet above its full flood pool level. High pool levels began to affect property and facilities upstream as well as raise concerns about dam safety. Peak pool stages at all three reservoirs were coincident with the real estate groundtaking line. For these reasons, increased retention beyond the range described above would not be prudent without assessing the need to acquire additional real estate holdings and evaluating the adequacy of remedial works upstream of the reservoirs.

Revising reservoir operations by adjusting the release schedule at each of the Rock Island District flood control reservoirs was also examined as a means of reducing impacts of the 1993 flood. As mentioned in the discussion on increasing reservoir retention, operation of all three reservoirs deviated from approved regulation plans during the 1993 flood.

Based upon a limited analysis, minimal impact would have been realized from increasing releases earlier in the course of the flood to conserve storage that could have been used at a more critical time. Increasing releases when the reservoir is at lower elevations would cause more frequent downstream flooding by not optimizing available storage. It must be emphasized that optimal operation of flood control reservoirs is accomplished by providing flood damage reduction for frequent, less severe flood events, as well as rare, large magnitude events.

Case Study - Revised Operation, Missouri River

Flows within the upper Missouri River Basin are controlled by six main stem dams and an additional 15 Corps of Engineers and Bureau of Reclamation tributary projects. The farthest downstream dam on the Missouri River main stem is Gavins Point Dam at RM 811.1. During the July 1993 peak flooding period, reservoir releases from Gavins Point Dam averaged 8,000 cfs. Release volume from Gavins Point Dam totaled 2.06 million acre-feet from June through August 1993. Reservoir release rates corresponded with minimal releases required for downstream water uses. The minimal flow released from Gavins Point Dam had no effect on downstream flood levels. Further reduction of reservoir releases during the 1993 flood event would not have been practical or beneficial. Refer to the 1993-1994 Missouri River Main Stem Reservoir Annual Operating Plan report for details regarding system inflow, pool levels, and operation of the main stem reservoirs.

Case Study - Additional Reservoirs

During the 1960's, five reservoirs for the Meramec River Basin were proposed in the St. Louis District. The operation of these reservoirs, if constructed, would not have significantly affected the 1993 flood peak stages because damaging rainfalls generally did not occur in the Meramec River Basin until well after the 1993 crest.

In the Rock Island District, three additional flood control reservoirs on tributary streams in Iowa had been proposed but never constructed in the 1960's and 70's. These are Jefferson Reservoir on the North Raccoon River, Ames Lake on the Skunk River, and Gilbert Reservoir on Squaw Creek which is a tributary to the Skunk River. A limited analysis of these reservoirs showed that, for the 1993 flood, these reservoirs would have had little impact on reducing peak stages. This was primarily due to the limited storage capacity set aside for flood control relative to accumulated runoff during the 1993 flood. Further discussion of these reservoirs can be found in Chapter 9 and in the Hydraulics appendix to this report.

Case Study - Reservoir Antecedent Conditions

A brief analysis was performed to evaluate 1993 reservoir releases from the six main stem dams for different antecedent conditions in the upper Missouri River basin. An extended drought occurred in the upper Missouri River basin from 1987 through 1992. At the beginning of March 1993, reservoir storage within the six main stem reservoirs was at 43.0 million acre-feet (MAF) or 12.4 MAF below normal. The lowest reservoir storage total since 1967 when all the reservoirs were first filled to their normal operating pool was 40.8 MAF which occurred in January 1991. During the 1993 flooding on the Missouri and Mississippi Rivers, the Missouri River main stem reservoir system stored a significant volume of runoff. Gavins Point Dam released minimal flows well below normal releases for the flood period in order to alleviate downstream flooding to the maximum extent possible. During the 1993 flood, 2.2 million acre-feet was released from Gavins Point Dam. These releases are considered the minimum possible and would be different for other antecedent conditions.

An analysis was performed to evaluate reservoir releases for the following antecedent conditions in the upper Missouri River Basin: 1) reservoir pools at or near normal levels at the start of the 1993 flood; and 2) if conditions had been such that the reservoir pools were at the base of exclusive flood control pool elevations. This simplified analysis did not take into account all the various factors involved in operating the main stem reservoirs such as required reservoir releases, distribution and timing of the runoff, and the various operating constraints of the reservoir system. Operational criteria for the main stem system are outlined in the Missouri River Main Stem Master Manual.

Normal Conditions. Normal antecedent conditions were assumed to be represented by reservoir pool levels at the historical average end of month pool elevation for May (based on 27 years of record) instead of the lower 1993 levels which were due to drought conditions. At normal May end of month pool levels, there is approximately 14.4 million acre-feet of available storage in the six reservoirs. This would have been sufficient capacity to hold almost all of the 12.5 million acre-feet inflow into the reservoirs during the period June through August 1993. At the lowest reservoir, Gavins Point Dam, excess inflow from the Niobrara River would have been within what was released during the 1993 operation of the reservoirs. Although operation procedures may have varied, analysis determined that the excess inflow into Gavins Point Dam would have been less than the volume released during the actual 1993 operation of the reservoirs.

Assuming normal pool levels and following the current reservoir regulation criteria, a simple analysis determined an additional release of 10,000 to 20,000 cfs. The additional release is very minor and is only 2 to 4 percent of the 300,000 cfs at Rulo, Nebraska (RM 498), and the 750,000 cfs peak discharge at Hermann, Missouri (RM 97.9). Therefore, a significant increase in releases in 1993 which would affect downstream flood levels would not have been required if initial pool levels had been at normal levels.

Wet Conditions. Extremely wet antecedent conditions were assumed to be represented by reservoir pool levels at the exclusive flood control pool elevation. Assuming all six reservoir levels at the exclusive flood control pool level would constitute an extremely rare event that, based on operation of the reservoirs in compliance with the Missouri River Main Stem Master Manual, would be highly unlikely. In the 27 years since all the reservoirs were filled to their normal operating pool, the end of month May pool elevation at each of the six main stem reservoirs has been below the elevation of the exclusive flood control pool.

If antecedent conditions had been such that only the exclusive flood control zone were available in the main stem Missouri River reservoirs and ignoring the timing of inflow with releases, a simple volume analysis determined that approximately one-third of the inflow would have been captured by the reservoirs. Actual 1993 operation captured approximately 80 percent of the inflow. Although capacity to store nearly 100 percent of the inflow was available in 1993, minimal releases during the summer months were necessary for downstream water uses. The no reservoir alternative modeled with UNET assumed zero percent capture of inflow. Reservoir releases for extremely wet conditions are bracketed between computed results for the base and the no reservoirs alternative UNET models.

Conclusion. Analysis was conducted to evaluate the effects of reservoir releases for different antecedent conditions in 1993. A simple volume analysis determined that additional releases of a magnitude which would have significantly affected downstream flood levels would not have been required if pool levels had been at normal levels. Although reservoir regulation criteria may have required additional reservoir releases, the release rate would have been minimal in comparison to the magnitude of the 1993 event. Extremely wet antecedent conditions were represented by pool levels at the exclusive flood control zone. In this case, approximately one-third of the total inflow to the reservoir system would have been stored. However, reservoir pool levels within the exclusive flood control zone at the end of May have not occurred at any of the six dams and should be regarded as an extremely rare event. Downstream impacts would be bracketed between the UNET model computed results for the base condition and the no reservoirs alternative. The examination of antecedent conditions illustrates that, with the exception of extremely rare circum stances, main stem Missouri River reservoir volume would usually allow a release schedule of minimal releases which would not have significantly affected downstream flood levels during the 1993 event. Results of the evaluation are summarized in Table 8-8.

Table 8-8
Available Storage Based on the Average End of Month Pool for May
Missouri River Main Stem Reservoirs [1]

Main Stem Reservoir	Average EOM Pool for May (Ft M.S.L.)	May 31 1993 Pool Elevation (Ft M.S.L.)	Exclusive Flood Control Pool Top Elev. (Ft M.S.L.)	Total Storage Volume Available[2] (Ac-Ft)	Total Reach Inflow Vol.[3] Jun-Aug 1993 (Ac-Ft)
Fort Peck	2234.9	2213.3	2250.0	3,141,000	3,460,000
Garrison	1836.7	1822.9	1854.0	5,595,000	5,920,000
Oahe	1607.2	1600.2	1620.0	3,874,000	1,900,000
Big Bend	1420.5	1420.9	1423.0	117,000	110,000
Fort Randall	1357.2	1355.7	1375.0	1,579,000	430,000
Gavins Point	1205.6	1206.1	1210.0	110,000	680,000

Notes: **1** Reservoir data is based on available information and is subject to change.
2 Refers to the available storage volume between the May average end of month pool elevation and the top of the exclusive flood control elevation at each of the reservoirs.
3 Reservoir inflow volume in excess of reservoir storage is a controlled release according to reservoir regulation criteria as experienced during normal operation.

LEVEES

For the systemic analyses, it was shown that changes to the existing levee system could have major effects on river stages hundreds of miles downstream. The following case studies will show that even a small isolated levee change can affect river stages on the Mississippi and Missouri Rivers, both upstream and downstream, some distance from the levee that was altered. Levee case studies included analyzing both a limited floodfight by not allowing any additional height added to a levee and a floodfight where sandbagging was performed, in effect, to increase the height of the levee. Other case studies included increasing the existing 100-year flood protection to 500-year behind the Chesterfield-Monarch levee on the Missouri River, determining whether to buy out, build a levee/floodwall or a combination of the two to protect an urban area, increasing the height of the existing levee on the Mississippi River from the Missouri River confluence downstream to Cairo, Illinois, based on the "urban design flood," and analyzing an isolated levee setback on the Missouri River.

Case Study - Limited Floodfight

An alternative which limits floodfight activities to measures that maintain levee integrity without adding additional height to the levee, was modeled using the design levee crown as the overtopping elevation. Simulation of this alternative was conducted by the Rock Island District for the reach extending from Muscatine, Iowa, to Hannibal, Missouri. All of the levee districts in this reach were included in the analysis. The effects were most noticeable at the downstream end of the Rock Island District. Failure of the middle cell of the Sny Levee and Drainage District which protects 58,700 acres reduced stages below Quincy, Illinois, by 3 feet. The magnitude of this reduction can be attributed to changes in timing, causing the peak of the hydrograph and overtopping of the middle cell levee to occur simultaneously. Upstream, above Burlington, Iowa, reductions in stage due to limiting floodfight efforts were less than 1 foot since most of the levees in that reach did not overtop in 1993 or during the limited floodfight simulation.

Table 8-9 shows the impact of floodfighting levee raises on water surface elevations at a few key gages within the Rock Island District.

Table 8-9

Floodplain Management Assessment
Impact of Raising Agricultural Levees
Mississippi River - Muscatine, Iowa, to Hannibal, Missouri

Location	1993 Computed WSEL*	No Floodfight Levees Elevation Difference in Feet
Muscatine, Iowa	556.0	0.0
Burlington, Iowa	536.4	-0.8
Quincy, Illinois	490.0	-2.7
Hannibal, Missouri	476.0	-2.9

* Water Surface Elevation

Case Study - Floodfighting

The Columbia Levee District (RM 166.0 to RM 156.0) on the Mississippi River is the first agricultural levee downstream of St. Louis. The levee district fought the rising waters for weeks, but the levee was overtopped on the morning of 1 August 1993 and the floodwaters regained their floodplain. The levee design was a 2 percent annual chance (50-year) flood, but because of the valiant efforts of the floodfighters, the levee far exceeded the design. Within an hour after the Columbia Levee District overtopped, a measurable drop in stages was observed at St. Louis, 14 miles upstream of the levee district. The official peak at the St. Louis gage (RM 179.6) was 49.58

on 1 August, occurring about the same time the Columbia Levee District overtopped.

Floodfighting can affect stages both upstream and downstream of the floodfight area. The St. Louis District UNET model was used to simulate a no floodfight scenario at Columbia. The results showed that peak stage could be reduced as much as 1.3 feet at the St. Louis gage, but downstream stages could increase as much as 0.6 foot at the Chester gage (RM 109.9), if no floodfighting took place. This levee district protected 13,560 acres of farmland and 65 homes. This evaluation indicates that floodfighting could cause additional flooding upstream, but it could also reduce flooding downstream. If floodfighting was not occurring at the Columbia Levee District, the downstream community of Ste. Genevieve, Missouri (RM 123.5), might have flooded.

Case Study - Chesterfield-Monarch Levee

The Chesterfield-Monarch earthen levee extends for about 11.5 miles along the Missouri River from RM 38.5 to RM 46.0. This privately financed levee protects about 4,240 acres of floodplain lands. About 1,450 acres are currently developed with about 3.1 million square feet of commercial floor space. The levee breached during the 1993 flood. The flood frequency of the 1993 flood was above the 1 percent chance (100-year) flood in the Chesterfield-Monarch area. The local community is now in the process of recertifying the levee protection to the 1 percent chance flood, meeting Federal Emergency Management Agency (FEMA) standards.

Because of additional development in this area, the local community has requested the Corps of Engineers to study increasing the levee protection to a 0.2 percent chance (500-year) flood. The expectation is that a 500-year levee would not have broken during the 1993 flood event. This higher Chesterfield-Monarch levee measure was simulated using the UNET model to capture any impacts on the 1993 flood.

The flood elevation impacts of the higher levee were calculated upstream and downstream of the Chesterfield-Monarch levee area by the UNET model. The largest increase just upstream of the higher levee for the 1993 flood was 0.8 foot.

Case Study - Urban Protection of River des Peres

The River des Peres watershed comprises portions of east-central and south St. Louis County, and west-central and south St. Louis City. The watershed consists of 111 square miles of predominantly urban watershed. River des Peres enters the Mississippi River at RM 171.9. The task of this special study is to determine whether a buyout or levee/floodwall construction would be the less expensive plan for urban protection.

Flooding on the River des Peres occurs from two separate sources: Mississippi River backwater and locally heavy rainfall. Mississippi River backwater causes flooding on the lower portion of River des Peres and Gravois Creek when the St. Louis gage is above 36 feet. This report will address only the Mississippi River backwater flooding.

An existing line of temporary levee protection from the Mississippi River backwater was built after the 1973 Mississippi River flood. The levee protection on the St. Louis City property is to a stage of 45 feet, and levee protection in the St. Louis County area is to a stage of 42 feet on the St. Louis gage. To protect to these stages requires extensive pumping from portable and permanent pumping plants to alleviate interior flooding from existing combined sewers, seepage, and storm water.

To achieve urban protection for River des Peres similar to the city of St. Louis urban protection, a combination of levees, buyouts and floodproofing measures will coincide with interior control measures of pumps, closure gates, and pressure sewers. Urban protection from the

Mississippi River for River des Peres would require an elevation of 427.00 feet National Geodetic Vertical Datum (NGVD).

Case Study - MR&T Levees

The Congressionally authorized flood control project for the lower Mississippi River and Tributaries (MR&T) is designed to contain the "project flood" from Cairo, Illinois, to New Orleans, Louisiana. This MR&T design flood is defined as the greatest flood having a reasonable probability of occurrence without denoting a specific design frequency. This special study evaluates a similar system from Cairo, Illinois, to the mouth of the Missouri River.

The design of the "project flood" was reviewed in the 1950's. Some 35 different hypothetical combinations of historical storms were sequentially arranged to conform with frontal movements and synoptic situations consistent with those in nature, to determine the meteorologically feasible pattern that would produce the greatest runoff in the lower Mississippi River. This extensive analysis for the lower Mississippi River was not performed for the middle Mississippi River reach (Cairo, Illinois, to the mouth of the Missouri River at St. Louis, Missouri) for this assessment. The design for the middle Mississippi River was accomplished using the established "urban design flood."

The "urban design flood" is defined as a discharge of 1,300,000 cfs at St. Louis, Missouri, adjusted for additional discharge from the drainage area downstream of St. Louis, to a discharge of 1,460,000 cfs at Cairo, Illinois (Mississippi River flow only). At the time the urban levees were designed, this was considered to be the approximate discharge of the 1844 flood. Current frequency studies estimate that this discharge is at least a 0.2 percent annual chance (500-year) flood. The observed discharge hydrographs of the 1993 flood were adjusted upward to obtain a possible urban design discharge hydrograph and routed with UNET. The resultant elevations represent the height of the levees needed from St. Louis, Missouri, to Cairo, Illinois, to contain the urban design flood." For the Floodplain Management Assessment analysis, the "urban design flood" for the middle Mississippi River was considered to be similar to the "project flood" for the lower Mississippi River. The required levee heights were adjusted to account for various hydrologic uncertainties.

The flood elevation impacts of containing this design flood between levees extending from St. Louis, Missouri, to Cairo, Illinois, are significant. For example: 1) At the St. Louis gage (RM 179.6), the existing urban height flood protection levee would have to be raised about 5 feet; 2) for the Bois Brule Drainage and Levee District (RM 95.0 to RM 109.5), an agricultural design levee, the average levee height raise would be 11 feet; and 3) at the Cape Girardeau, Missouri, gage (RM 52.0), the urban protection levee and floodwall would have to be raised about 5 feet to contain a flood of similar magnitude used for the lower Mississippi River flood protection design.

Raising levees to contain the "urban design flood" within the St. Louis District would result in increased peak flows in the middle Mississippi River and could affect flood stages up to and including the MR&T project flood level in the vicinity of Cairo, Illinois. The evaluation of these potential impacts is complex and is beyond the scope of this analysis. However, any future studies that consider changes in the present middle Mississippi River levee system should include the evaluation of these downstream effects.

Case Study - Levee Setback

The UNET model was employed to analyze the effect of an isolated levee setback on flow conditions throughout the study reach in the Omaha District. Setback of a levee refers to moving the levee from the present location to a new location which is farther from the river. Levee setbacks are intended to increase the cross section flow width instead of constricting the flow area to a narrow channel. However, the flow area increase may be offset by an elevated roughness condition. The isolated levee setback analysis illustrated how undesirable consequences may occur on the entire system from modifying a small section of the channel.

This isolated setback location selected for the case study was the L-550 and L-536 Federal levee units located on the left bank of the Missouri River between RM 542.1 and RM 516.3. Within the reach, Missouri River channel width averages 800 feet. Existing Federal levees are set back from the channel between 1,000 and 3,000 feet. Private levees have been constructed adjacent to the Missouri River channel bank within most of the reach. The area between the private levee and the Federal levee is generally agricultural row crops. In the 1993 event, L-550 levee capacity was exceeded for a significant period of time, with levee overtopping for a total length of 1 to 2 miles at a depth of 1 to 2 feet. On the morning of 24 July, the L-550 levee breached approximately 1.5 miles upstream of Brownville, Nebraska, at RM 536.7. Levee unit L-536 did not overtop or breach during the 1993 event. Private levees within the Rulo overbank area downstream of L-536 suffered extensive damage and essentially had no constricting effect on flow during the peak flow period.

Levee setback distance was determined by computing how much the water surface elevation was lowered in the setback reach. The levee breach at L-550 was assumed to have been directly dependent upon water surface level. Therefore, ignoring the effects of duration and seepage, the levee was assumed to remain intact if computed water surface elevation was less than the elevation at which overtopping occurred in 1993. Brief iterative analysis indicated that a levee setback distance of 3,000 feet lowered the water surface in the setback reach so that overtopping or breaching did not occur.

Downstream of unit L-536, the Rulo overbank area contains only private levees. The downstream end of the levee setback was selected to provide a reasonable tie-in point and minimize downstream impacts. For cost analysis, the existing levee was removed at the 10-percent ratio employed within the levee removal alternative. Construction of a new levee was assumed along the setback alignment.

Increasing the setback distance by 3,000 feet would affect roughness values within the cross section. Estimating what cross sectional changes would occur, such as vegetative growth, sediment deposition, etc., is highly speculative and was not investigated. Roughness for the area between the existing levee and setback levee locations may increase due to changes in land use which would increase stages in the area of the setback. Unless the Missouri River bank private levees were removed, the area between the Federal levee and the riverbank would probably remain agricultural row crop. The possible combinations of land use, geometry, and roughness changes were not examined for their effect on computed results.

Case Study - Interior Drainage

If a levee does not overtop or breach, the interior area behind the levee may still experience extensive flooding when high stages on the exterior prevent drainage structures through the levee from removing interior runoff. An example of this would be Hamburg, Iowa, where flooding by the Missouri River and Nishnabotna River was prevented by Federal levee L-575 and its tieback. However, the lack of ability to drain the interior area due to high stages on the Nishnabotna and Missouri Rivers blocking the drainage structures through L-575 and rainfall amounts of over 18 inches during July 1993 caused extensive flooding to the city of Hamburg and surrounding agricultural lands. This was also the case behind many of the Federal levees on the Missouri River.

For the various systemic alternatives, the altering of the stage hydrograph on the Missouri River will affect the interior areas behind the Federal levees. Two of the major effects will be restricting the outflow of drainage structures and increasing the amount of seepage into the overbank from the Missouri River. This is discussed in the following case studies along with the elimination of the interior runoff through the use of pumps.

Case Study - Drainage Structures

A case study of a typical interior drainage structure through the Federal levee was performed to illustrate impacts of the various alternatives on interior drainage. The invert of a drainage structure through levee L-575 at RM 554.4 was compared with the Missouri River stage hydrographs for existing conditions, 10 percent runoff reduction and no reservoirs alternatives. This would bracket the greatest potential change of the stage hydrograph.

The stage of the Missouri River is so great and the duration so long that altering the stage hydrograph would not have helped or hampered the functionality of the existing drainage structures during the 1993 flood. The duration of flow above the invert of the drainage structure at RM 554.4 was compared with existing conditions for both the 10 percent reduction and no reservoirs alternatives. Because the interior water at this location ponded to about elevation 910, there would have been one additional day that water could have drained for the 10 percent reduction alternative. Since the baseline condition was below elevation 910 for about 25 days during August, this would represent an increase of about 4 percent in the duration which the outlet could have drained during the 1993 event if the inflows were reduced by 10 percent.

Case Study - Seepage

When the Missouri River is high over an extended period of time, seepage of water into the levee-protected lands becomes a problem. Because seepage occurs when gravity drainage is not possible, pumping or ponding are the only alternatives for addressing the problem. The three important factors for seepage are Missouri River stages, duration of high stages, and seepage rates.

For the alternatives, the altering of the flood hydrograph would alter the amount of seepage that may occur depending upon the change in stage and the duration, thereby increasing the amount of seepage into an interior area. As an example, the stage increase at Rulo, Nebraska, for the confined levees alternative was compared to the existing conditions to determine the maximum increase in stage and duration. Using data obtained from the seepage analysis for the Thurman to Hamburg study (USACE, 1993) for Federal levee L-575, the 2- to 7-foot increase in stage for the 20 extra days would add approximately 1,200 acre-feet of seepage into the Rulo overbank area. This assumes a levee length of about 35 miles (RM 515 to RM 480). With an area of about 88,600 acres and runoff for the month of July 1993 being well over 1 foot, this would add less than 2 percent to the total volume of water in the Rulo overbank. Therefore, the negative impact of seepage into the overbank areas caused by increasing the stage on the Missouri River is considered negligible.

Case Study - Pumping

The two major alternatives for removing interior runoff when drainage structures are not functioning are pumping and/or ponding. Due to the limited extent of this study, ponding or the combination of pumping and ponding was not investigated.

One of the alternatives is confined levees with no overtopping or breaching of the levees. This will not allow any water from the Missouri River to flood the overbank behind the levee. As an example of the amount of pumping capacity required to remove the interior drainage runoff from behind the Federal levees for the July 1993 rainfall event, data obtained from the Thurman to Hamburg study, for Main Ditch 6, was used. Main Ditch No. 6 is a 67-square-mile basin that drains through levee L-575. The criterion for pumping is to not allow any agriculture land to be inundated for more than 48 hours. On average, crops that are under water for longer than 48 hours are considered destroyed. Based on this criterion, to fully remove the interior runoff from the 18 inches of rain (minus infiltration) that fell on the Main Ditch 6 basin during July 1993, pumps with a total capacity of approximately 4,000 cfs would be required. While this is not practical from the standpoint that the Main Ditch 6 channel capacity is about 1,000 cfs, it does give an idea of the magnitude of the 1993 event and how very little could have been done to relieve interior flooding.

To apply this to other interior areas on the Missouri River overbank, the 4,000 cfs pumping capacity was divided by the 67-square-mile basin area. This would require a pumping capacity of about 60 cfs per square mile of drainage area. Within the Omaha District, the total overbank area behind Federal levees and private levees between Omaha, Nebraska, and Rulo, Nebraska, is 414 square miles. The total overbank area was multiplied by an additional 20 percent to account for the runoff from the hills. Therefore, the pumping requirements for the total area of approximately 500 square miles would be about 30,000 cfs. It should be noted that interior drainage is very site specific and each potential pumping site would require a detailed study.

In conclusion, the 1993 flood event would have overwhelmed any sort of pumping facilities designed for protection of agricultural lands.

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FINDINGS

8-a) All study computations were performed for the 1993 event only. Extrapolating conclusions obtained from analysis of 1993 event modeling may be erroneous with respect to other events.

8-b) From a hydraulic analysis perspective, the FPMA analysis illustrates that no single alternative provides beneficial results throughout the system. Applying a single policy systemwide may cause undesirable consequences at some locations. Examination of many factors such as computed peak stages, discharges, flooded area extent, and depth within flooded areas is necessary to evaluate how an alternative affects performance of the flood damage reduction system as a whole.

8-c) The importance of evaluating hydraulic impacts systemically is clear from the results of the unsteady state hydraulic modeling. Changes that affect the timing of flood peaks or the "roughness coefficients" of the floodplain can be as significant as changes in storage volume.

8-d) Flood peaks may be reduced if increased floodplain storage is provided, and flood peaks may increase if storage volume is reduced (e.g., by levees constricting the river). However, the timing of flows from tributaries, or the effects on timing of flows due to increased storage, can be just as important, along with the "roughness coefficients" of the floodplain.

8-e) Levee profile surveys of all Federal levees, an inventory and profile surveys of all private levees, and a database on interior drainage and ponded areas are a prerequisite to being able to further advance the reliability of hydraulic modeling.

8-f) Some levee areas along the Missouri River experienced flood damage in the 1993 event as a result of the long duration of precipitation and flooding, exceeding the design standard of interior drainage facilities. Problems with interior drainage facilities also included sediment deposition, erosion, and deterioration of the structures since construction.

8-g) Hydraulic routings assuming agricultural levees are removed show that, with continued farming in the floodplain, 1993 stages would be reduced an average of 2 to 4 feet on the Mississippi River in the St. Louis District. If this area would have returned to natural forested conditions, most of the system would still have shown reductions in stage (up to 2.8 feet), but increases in stages by up to 1.3 feet would also be seen in a few locations. In the Kansas City District, hydraulic modeling shows changes in stages of -3 feet to +1 foot for no levees with agricultural use and -3 feet to +4.5 feet with forested floodplains.

8-h) If the agricultural levees along the upper and middle Mississippi River had been raised and strengthened to prevent overtopping in the 1993 event, the flood stages on the middle Mississippi River would have been an average of about 6 feet higher. Likewise, raising the levees to prevent overtopping on the Missouri River would have increased the stage by an average of 3 to 4 feet, with a maximum of 7.2 feet at Rulo, Nebraska, and 6.9 feet at Waverly, Missouri.

8-i) Although the Agricultural Levees Removed alternative with <u>continued agricultural use</u> of the floodplain shows the greatest stage reduction, exposure to flooding under this alternative is increased in the existing agricultural leveed areas. Risk of flooding at urban areas was shown to decrease or increase, depending upon impacts caused by factors such as hydrograph timing.

8-j) Although the Agricultural Levees Removed alternative with <u>natural floodplains</u> shows the least stage reduction, exposure to flooding under this alternative is decreased because the existing agricultural leveed areas would no longer exist. Risk of flooding at most urban areas would remain the same for this alternative..

8-k) Modeling results demonstrated that agricultural levee removal does not always provide uniform stage and discharge reduction. When levees are overtopped, they act as detention dams, skimming volume off the peak portion of the hydrograph. When levees are removed, the flow continues downstream in the enlarged floodway. As a result, higher flows may be experienced downstream at critical facilities and urban areas, causing increased stages at these locations.

8-l) Hydraulic modeling has shown that localized levee setbacks can increase flood stages downstream by creating a new bottleneck, and that a forested floodplain can increase stages similar to a levee constriction.

8-m) Hydraulic modeling of reducing the runoff from the upland watersheds by 5 and 10 percent predicted average stage decreases of about 0.7 foot and 1.6 feet, respectively, on the upper and middle Mississippi River and about 0.4 foot and 0.9 foot, respectively, on the lower Missouri River. However, wetland restoration measures alone would not have achieved this level of runoff reduction for the 1993 event because of the extremely wet antecedent conditions. Restoration of upland wetlands would produce localized flood reduction benefits, but would have little effect on main stem flooding caused by the 1993 event.

8-n) Wetlands may reduce local flooding in the uplands by up to 25 percent where contributing areas are small. Restoration of such wetlands would not have affected flooding in the lower floodplain reaches for the 1993 event because most depressional areas were already full of water throughout the watershed, as normally occurs during major flood events.

8-o) The potential to reduce flooding with further upland measures varies. In the watersheds that contributed the greatest percentage of runoff, wetlands and revised agricultural practices would have had minimal effect for the 1993 event. Major structural flood control storage reservoirs would be required to achieve the additional 10 percent volume reduction used for the analysis.

8-p) Several of the alternatives altered hydrograph timing. A complete evaluation is required prior to implementing any alternative to investigate performance for a variety of events with different inflow characteristics.

8-q) Results of the levee removal alternative illustrated that all model results which determine a stage and discharge reduction are extremely dependent upon assumptions regarding floodplain use and flow roughness. A change in channel or overbank roughness from the conditions assumed may significantly alter computed results.

CHAPTER 9 - EVALUATION OF "ACTION ALTERNATIVES"

INTRODUCTION

The "Action Alternatives" have previously been defined as those alternatives that would affect the hydrologic and hydraulic conditions in the floodplain. The alternatives being evaluated are shown below. Each of the action alternatives will be evaluated for the same impact categories as was done with the policies and programs in Chapter 7, which assumed those measures were in place at the time of the Midwest flood of 1993.

It is certainly understood that none of these action alternatives would likely be appropriate or implementable for entire river reaches. The analyses are intended to bracket the impacts of a single alternative at a time, to provide insights into which alternatives have the most merit for certain conditions and may best be combined with another alternative or a policy/program change to optimize use of a specific section of the floodplain. This assessment was not able to analyze combinations of alternatives or alternatives with various scenario measures as a backdrop. These types of analyses would be helpful prior to implementation of changes to floodplain policies or the development of a recommended plan for any portion of the floodplain.

The location of the discussion in this chapter for each of the alternatives is noted.

Agricultural Levees

K - Limited Floodfighting (page 9-2)

L - Removing All Agricultural Levees (page 9-6)

M - Setting Back Agricultural Levees (page 9-11)

N - Establishing Uniform Height Levees (25-year Frequency) (page 9-16)

O - Raising Levees Above the 1993 Flood Levels (page 9-20)

Urban Levees

P - 500-year Protection (page 9-24)

Critical Facilities

Q/R - 500-Year Protection for Critical Facilities Sites (page 9-38)

Upland Retention/Watershed Measures

S - Removing Existing Reservoirs (page 9-39)

T - Added Reservoirs (page 9-46)

U - Revised Operation of Reservoirs (page 9-51)

V/W - Reducing Upland Runoff by 5 or 10 percent (page 9-52)

The five Corps of Engineers Districts addressed those action alternatives that had the most relevance in their District due to the size of the 1993 flood, the current use of the floodplain, and regional issues in their District. The letters "K through W" on the above list also represent the columns of each alternative ex-amined for impact assessment in each District's matrix table, as found at the end of this chapter and again, with footnotes on the cell entries, in Attachment 5 at the end of the main report. Cell entries in the matrix tables show the incremental changes from the 1993 flood base condition that could be expected. Further details of this evaluation are provided in the Evaluation appendix (Appendix B) to this report.

LIMITED FLOODFIGHTING ON AGRICULTURAL LEVEES

There were no systemic hydraulic routings performed relative to this alternative, but the analyses are based on past experience relative to floodfight efforts in the Rock Island and St. Louis Districts.

ALTERNATIVES ADDRESSED BY RESPECTIVE DISTRICTS

District	Action Alternatives												
	K	L	M	N	O	P	Q	R	S	T	U	V	W
Omaha		X	X	X	X				X			X	X
Kansas City		X	X	X	X	X			X				
St. Paul						X			X			X	X
Rock Island	X	X	X	X	X	X	X	X	X	X	X	X	X
St. Louis	X	X	X	X	X	X			X	X	X	X	X

Implementation of a plan to limit flood-fighting in certain areas due to the adverse effects it may have on others has legal ramifications and would require agreements between all parties prior to the flood event. Continued discussion regarding a uniform policy on floodfighting between States is essential, since modern construction equipment is likely to increase the ability to raise levees in an emergency situation, increasing hydraulic impacts on others. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Column K of the matrix tables at the end of this chapter.

(Rock Island District Discussion - "Limited Flood Fighting")

Background. Considerable resources were expended on agricultural levees fighting the Midwest flood of 1993. The agricultural levee floodfight consisted of the following activities. Costs are summarized in Table 9-1.

a. Structural Floodfight - Measures were taken to maintain the structural integrity of the base levee. Typical actions include underseepage control by constructing a ring of sandbags around boils and backslope treatment for levee through-seepage on sand levees. Structural floodfighting would continue to be performed as a necessary emergency measure to protect life, property, and safety. Measures include filling and placing 2,500,000 sandbags and placing 2,500 rolls of 100-foot polyethylene sheeting.

b. Levee Elevation Floodfight - As the flood of 1993 was projected to rise above the elevation of the base agricultural levees, actions were taken by the Levee and Drainage Districts to raise the level of protection. Levees were usually raised by using sandbags or pushing up the landward side slope with a bulldozer. One drawback of the push-up method is that it weakens the levee by reducing its cross section stability. Measures include filling and placing 7,500,000 sandbags and placing 7,500 rolls of 100-foot polyethylene sheeting.

c. Levee Grade Restoration - Agricultural levees that were elevated during the emer-gency floodfight had to be restored to their original dimensions. The pushed-up material was re-graded to restore the original section.

Table 9-1
Floodplain Management Assessment
Floodfighting Costs for Agricultural Levees (1)
Mississippi River - Muscatine, Iowa, to Hannibal, Missouri

Category	Cost ($000)	Total ($000)
Structural Floodfight		
Labor	1,190.0	
Travel	118.0	
Floodfight Supplies/Distribution	125.0	
Overhead	217.0	
Equipment Rental Contracts	694.0	
Sandbags		
Procurement - 2,500,000 Sandbags	653.0	
Fill and Place Sandbags	1,880.0	
Polyethylene Sheeting		
Procurement - 2,500 Rolls	76.0	
Place Polyethylene Sheeting	625.0	
Miscellaneous	235.0	5,810.0
Levee Elevation Floodfight		
Sandbags		
Procurement - 7,500,000	1,960.0	
Fill and Place Sandbags	5,630.0	
Polyethylene Sheeting		
Procurement - 7,500 rolls	229.0	
Place Polyethylene Sheeting	1,880.0	
Push Up Levee Backslope (2)	13,700.0	
		23,400.0
Levee Grade Restoration		
Regrade Levee (3)	13,700.0	
		13,700.0
		42,900.0

Sources: *The Great Flood of 1993 Post-Flood Report, Upper Mississippi River Basin*, Appendix B, U.S. Army Corps of Engineers, Rock Island District, September 1994, Table 30, including staff assessment of costs to study area.

Notes:
(1) The true costs of the agricultural levee floodfight cannot be accurately calculated due to a lack of documentation. The above table reflects a reasonable estimate of the magnitude of the costs.
(2) Levee push-ups typically ranged from 3 to 5 feet. Not all levee and drainage districts used push-ups for the floodfight.
(3) Regrade levee to pre-flood configuration.

Continue Existing Floodfighting Practices. Floodfighting would continue under the present set of practices. Actions would be taken to maintain the structural integrity of agricultural levees. In cases where flood levels were projected to rise above the base levee elevation, sandbags and push-ups would be accomplished by the levee and drainage districts to prevent overtopping. Federal, State, and local governments would continue to fund the floodfight at a level sufficient to accomplish the necessary emergency measures.

Limit Emergency Response to Agricultural Levees. A limited response plan would maintain floodfighting for structural integrity, but would eliminate any levee raises. Levees would overtop more often than presently is the case.

Restrict Floodfighting to Pre-Approved Levees. Actual experience from the Midwest flood of 1993 shows that most floodfighting costs were attributed to Federal levees and levees in the Corps of Engineers administered Public Law 84-99 inspection program. Categories most likely to attain a pre-approved status for floodfighting would be: (1) Federal levees and (2) Public Law 84-99 eligible levees. Relatively few resources were expended on non-Federal, non-Public Law 84-99 eligible levees during the flood of 1993. Therefore, there is little opportunity for savings by restricting floodfighting to pre-approved levees.

Hydrology and Hydraulics. UNET simulation of this alternative showed that the effects of prohibiting levee raises during floodfighting operations were most prominent at the downstream end of the Rock Island District. Upstream of La Grange, Missouri, reductions in stage were generally 1 foot or less as the 1993 observed flood profile was below the design crown of the levees in many cases. However, below Quincy, Illinois, stages were reduced by as much as 3 feet. Some of that decrease in stage can be attributed to the failure of the middle cell of the Sny Levee and Drainage District which protects 58,700 acres. That levee cell failed during the UNET simulation of the no floodfight alternative but did not fail during the 1993 flood.

Floodfighting can also change the timing at which failures occur. The effects that timing of levee failures have on river stages can be significant. Table 9-2 shows the impact of floodfighting levee raises on water surface elevations at a few key gages within the Rock Island District.

Cultural Resources. Floodfighting that prevents overtopping has an obvious positive impact on historic structures in the floodplain. It can also prevent damage to archaeological sites that occurs from erosion in the vicinity of levee breaches. Negative impacts of floodfighting on archaeological sites are fairly minimal because activity is limited to the exist-ing disturbed levee right-of-way; however, adverse impacts can be significant when equipment staging areas are placed in nearby fields. In general, floodfighting impacts are judged to be quite positive for both historic structures and archaeological resources compared to operating the existing system without flood fighting ($^{-5}$.....^{0}...$_{+4}$.$^{+5}$). (The rating reflects the degree and nature of the potential archaeological or historical impacts as rated on a scale of -5 to +5.)

<u>(St. Louis District Discussion - "Limited Floodfighting")</u>

Background. St. Louis District did not specifically identify values for inclusion in the matrix table for "Limited Floodfight" in this Floodplain Management Assessment. However, significant resources were expended on agricultural and urban levees floodfighting in 1993 within the St. Louis District, and useful experience has been gained. Therefore, some general observations and concerns regarding "Limited Floodfighting" have been identified for the St. Louis District area to provide a useful insight based on the experience of an area significantly involved in floodfighting efforts.

Table 9-2
Floodplain Management Assessment
Impact of Floodfighting Agricultural Levees Raises
Mississippi River - Muscatine, Iowa, to Hannibal, Missouri

Location	1993 Computed WSEL*	No Floodfight Levees Elevation Difference in Feet
Muscatine, Iowa	556.0	0.0
Burlington, Iowa	536.4	-0.8
Quincy, Illinois	490.0	-2.7
Hannibal, Missouri	476.0	-2.9

* Water Surface Elevation

Two reports have been prepared discussing in detail 1993 St. Louis District floodfight efforts as follows:

1. "After Action Report, Midwest Flood of 1993, THE GREAT FLOOD OF '93," March 1994, prepared in compliance with Engineering Regulation 500-1-1, U.S. Army Engineer District, St. Louis.

2. "THE GREAT FLOOD OF 1993 POST-FLOOD REPORT, UPPER MISSISSIPPI RIVER BASIN," APPENDIX C, ST. LOUIS DISTRICT, September 1994.

Reference 1. above indicates (pages 65-67) that total flood damages in St. Louis District (as of June 1994) were $1,387,000,000 and total flood damages prevented by levees, floodwalls and reservoirs were $5,401,000,000. Were it not for the successful operation of existing levees, floodwalls and reservoirs, along with the incremental increases in the levels of protection achieved through emergency levee raises and maintenance of levee and floodwall integrity, the flood damages in St. Louis District in 1993 would have been $6,788,000,000 or 4.89 times greater than what actually occurred. The signi-ficant economic benefits of flood protection projects and emergency floodfighting efforts are only the "tip of the iceberg" when family, societal and community stability impacts are evaluated. The economic and social worth of securing and enhancing the utility of the existing levees, floodwalls and reservoirs in St. Louis District was demonstrated by the 1993 flood event.

Reference 2. above presents 16 issues and problems experienced before, during and following the 1993 flood event as "LESSONS LEARNED." Two of those lessons learned have relevance to the discussion of limited floodfighting, so those issues, discussions and recommendations are identified as follows:

1. Issue No. 1: "Deciding When to Cease Floodfighting Efforts."

Discussion No. 1: "Criteria need to be developed on what stage or elevation to cease Corps floodfight assistance in certain areas where there is a safety concern or when the economic value of the effort is questionable." Recommendation No. 1: "While it is doubtful that local floodfight efforts would cease, written criteria would permit the uniform procedure for the termination of Corps assistance. It would also permit the uniform explanation of withdrawing Corps assistance to State and Federal officials who would be contacted by local officials. This could also help in removing the difficulty in explaining the authority to spend large sums of money for floodfighting and not having the authority to fund increases in the level of flood protection."

2. Issue No. 6: "Comprehensive Upper Mississippi and Illinois Rivers Flood Plans."

Discussion No. 6: "The 1993 flood proved the lack of such a plan for both rivers. The concerns of local officials increased over the ability to react with an overall plan in place or reacting on an area by area basis."

Recommendation No. 6: "Local interests and the Corps should work together to pursue the necessary legislation and funding required to prepare a plan for each basin."

Analysis of "Limited Floodfighting."

It is important to recognize that the authorized mission assignment of the Corps of Engineers during nationally declared flood disasters is to minimize flood damages and the loss of life. This flood disaster mission assignment is very different from the regular Corps water resources mission. The Corps mission assignment for other than flood emergency actions requires significant reliance on economic efficiency criteria, which do not seek to obtain the maximum reduction in future flood damages. Instead, the normal approach to flood damage reduction is based on recommending the level of flood protection that maximizes net National Economic Development benefits. This approach seeks to identify the "optimum" level of flood damages that can be prevented. This means that there can be significant flood damages remaining after project completion. The possibility of limiting floodfighting efforts is more reflective of the normal Corps project evaluation process than it is of the authorized Corps flood emergency mission. The rationale for this approach, from a systemic perspective, is that it considers the possibility that limiting floodfighting at some locations may lead to substantially greater avoidance of damages at other locations.

Some means to integrate floodfighting efforts for existing flood damage protection projects into a more efficient system would be useful. An integrated floodfighting system could address damage reduction needs that are compatible with floodplain ecosystem functions and which recognize the economic, social well-being, safety, and environmental consequences (including residual risks), and the needs of less affluent floodplain occupants. The lower Mississippi River enjoys a more uniform approach to flood control and floodfighting through the efforts of the Mississippi River Commission.

Summary of "Limited Floodfighting."

The 1993 flood provided a demonstration of the economic value and significant societal worth of the existing system of levees, floodwalls and reservoirs, along with emergency floodfighting efforts. Preparation of a fully coordinated and comprehensive plan for conducting future floodfight efforts, which includes consideration of when to cease or limit Corps floodfight assistance, would be a valuable tool for improving future flood responses.

REMOVING ALL AGRICULTURAL LEVEES

The alternative of removing all agricultural levees was evaluated as a systemic hydraulic model on the Mississippi and Missouri River main stems. The Omaha, Kansas City, Rock Island, and St. Louis Districts have provided an evaluation of the impacts of this alternative. The estimated changes in impacts from those actually experienced at the time of the 1993 flood are noted in Column L of the matrix tables at the end of this chapter.

(Omaha District Discussion - "Removing all Agricultural Levees")

Introduction. For this alternative, all agricultural levees were removed. Hydrologic analysis was performed for both natural and agricultural conditions within the floodplain area. Two options were considered: complete removal of the existing levees or removal of 200-foot sections every 2,000 feet.

Change in Stages. Levee removal provides a means of reducing computed stages. Stage reduction is extremely dependent upon floodplain use which was shown by results from the agricultural and natural conditions. Stage reduction generally varied from -3 to -4.5 feet for the agricultural condition and from -0.7 foot to -2.3 feet for the natural condition. Peak discharge reduction only varied by approximately -10,000 cubic feet per second (cfs) for the agricultural condition and varied from -20,000 cfs to -40,000 cfs for the natural condition.

At Rulo, Nebraska, the existing private levees were non-effective and severely damaged in 1993 to the extent that the floodplain was essentially a "no levee" condition. Comparing model results to the actual 1993 stages, the model stage was -1.3 feet lower for the agricultural condition and +2.0 feet higher for the natural condition. Results at Rulo, Nebraska, illustrate that the model results for agricultural and natural conditions bracket the actual stage and provide a reasonable basis for expected results in a "no levee" condition.

Change in Flood Damages. To remove the Federal agricultural levees would have added over $71 million damage to the 1993 flood impact to Omaha District.

Change in Government Expenditures. Government expenditures for emergency response, disaster assistance, and Federal Crop Insurance Corporation (FCIC) and National Flood Insurance Program (NFIP) indemnities were estimated to increase by over $52 million. A portion of the indemnities would be prepaid by participants.

Change in Value of Floodplain Resources. Real estate values could be significantly decreased because of lower expected future income-producing capacity. The effect could be extremely large and very burdensome to affected landowners, communities, businesses, local taxing authorities and others. The decreases in value and any costs of dislocation, relocation, and mitigation would show up partly as financial costs and partly in decreased economic activity in the area. To estimate the total change in value of floodplain resources is beyond the scope of this assessment and requires an analysis of annualized costs and benefits. This is discussed in the section on sensitivity of results at the end of this chapter.

Change in Risk. Several small towns, railroads, and highways including I-29 would be permanently more vulnerable to flooding as would a very large number of acres of extremely good cropland.

Change in Environmental and Cultural Resources. Levee removal would have an overall positive impact on many aspects of the environment. If it were assumed that currently marginal cropland (wet at least 2 out of every 5 years, for example) would revert to natural conditions, it could change to wetlands, riparian grassland, and perhaps eventually succeed to riparian forest. This would restore the habitat diversity of the floodplain as well as maintaining the early successional stages of the floodplain ecosystem, which would benefit the species that inhabit the floodplain.

Agricultural levee removal would have a negative effect on cultural resources due to increased flooding and the potential disposal of spoil on prehistoric or historic sites.

Implementation Costs. To remove sections of the existing levee would cost about $8.5 million. To remove the levee completely would cost close to $92 million. Costs of environmental and cultural mitigation, relocation of residents or businesses, and effects on local schools, communities, and relevant taxing authorities were not quantified for project costs.

Summary. River stages are decreased, but higher flows may be routed downstream. Obviously, large areas that had been protected by levees, including agriculture, small towns, infrastructure, and critical facilities, would now be flooded. Environmental benefits, on the other hand, could be considerable. Depending on what was allowed to grow in the floodplain, whether the existing channel was maintained, and sedimentation, conveyance could actually decrease.

(Kansas City District Discussion - "Removing all Agricultural Levees")

This action alternative assumes that Federal and non-Federal agricultural levees are removed, and levees identified as urban levees remain in place.

Change in Stages. The analysis of this alternative includes two sets of changes in stage depending on whether crop production is continued in the overbank flooded areas or whether overbank flooded areas have been allowed to return to "natural conditions"; e.g., trees in the overbanks.

Assuming continued crop production in the overbanks, all reaches except Hermann would have reductions in 1993 flood elevations of 0.1 foot to 3.0 feet. The 1993 flood elevation would increase by about 1 foot in the Hermann reach.

Assuming trees in the overbanks, three of the five reaches would have reductions in 1993 flood elevations (-0.7 foot to -2.9 feet). The Boonville and Hermann reaches in the downstream portion of the Missouri River, however, would experience higher 1993 flood stages (increases of 1.8 feet and 4.6 feet, respectively).

Change in Flood Damages. Removing agricultural levees and assuming crops in the overbanks may reduce residential flood damages an estimated 7 percent and Other Urban flood damages by about 10 percent. Approximately six communities would no longer flood due to reduced stages and because an urban levee that overtopped in 1993 would not overtop under this alternative. However, an estimated three new communities would be flooded because they are protected by agricultural levees that did not overtop in 1993 but are removed under this alternative. Other communities would stil flood, but in four of the reaches, damages are assumed to be lower because stages are lower. In the Hermann reach, damages would be higher due to the increased stage.

If it is assumed that the overbank flooded areas have been allowed to return to "natural conditions," Residential flood damages might be reduced by about 2 percent and Other Urban damages by about 6 percent. With this assumption, an estimated five communities would no longer flood and three communities not flooded in 1993 could now have flood damage. Other communities in the St Joseph, Kansas City and Waverly reaches in the upstream portion of the District would still flood but may have reduced damages because of reduced stages. Communities in the Boonville and Hermann reaches in the downstream area would experience increased 1993 flood damages because of increased stages.

Assuming continued crop production in the overbanks and with agricultural levees removed, Agricultural and Other Rural damages are estimated to increase by about 2 percent because crop acres flooded would increase by about 15,900 acres. If the assumption is made that some of these crop acres would revert to "natural conditions" (environmental use) because they no longer have protection from levees, then 1993 Agricultural and Other Rural flood damages would be expected to increase by less than 0.5 percent. This estimate assumes that about 12,700 crop acres might revert to environmental use and no longer be used for crop production. Fewer crop acres farmed would mean decreased crop damages, but with this assumption, there is still an overall net increase in crop acres flooded of about 3,200 acres.

Change in Government Expenditures. Emergency response costs are expected to decrease overall because of reduced stages and decreased floodfight costs. An insignificant change would be expected in agricultural disaster relief costs because of the low (2 percent) to insignificant (0.5 percent) increase in crop damages under this alternative. Disaster relief costs relating to human resources could be expected to experience a low decrease based on the expected decreases in Residential and Other Urban damages. If agricultural levees are removed, more people may buy flood insurance. Although damages and thus National Flood Insurance Program payouts may decrease, the additional properties covered could offset the reduction due to decreased damages. If agricultural levees are removed and crop production continues in the overbanks, more farmers could be expected to purchase crop insurance. Thus, with slight to low increases in 1993 crop damages, and with more farmers covered by crop insurance, an increase in FCIC payouts could be expected with this alternative.

Change in Value of Floodplain Resources. With agricultural levees removed, the market value of crop acres affected could be reduced by about 20 percent overall. This estimate is based on an estimated change in value per acre for about 127,000 crop acres that used to have 100-year flood protection from Federal agricultural levees and now are unprotected; and for about 565,000 crop acres that used to have 5- to 25-year protection from non-Federal agricultural levees and now are unprotected. With the assumption of trees in the overbank flooded areas, net agricultural product would be drastically reduced since crops would no longer be produced on these acres. This would be somewhat offset by the value of use of the land for environmental purposes. Urban real estate values for acres affected could also be reduced about 20 percent overall. This is based on an estimated change in market value of land for the more than 12,000 other (non-crop) acres that are no longer protected by agricultural levees, and offset by increased land values in communities no longer flooded.

Change in Risk. No change is expected in the number of critical facilities that would be damaged with this alternative. Lack of detailed information about these facilities precludes a more detailed estimate. An estimated 2 percent decrease in the number of communities vulnerable is based on estimates of communities that no longer flood less new communities flooded with this alternative. The number of people who are vulnerable would also decrease based on the estimated decrease in communities flooded. The estimated 7 percent decrease in the number of residential structures flooded is based on rough estimates of structures in communities that no longer flood and structures in communities that could now flood with this alternative.

Other Implementation Costs. Removing agricultural levees and leaving cropland and other (non-crop) land unprotected could necessitate compensating landowners for any resulting decline in property values. More than 127,000 crop acres and nearly 5,200 other (non-crop) acres that were protected by 100-year Federal agricultural levees are without protection under this alternative. Approximately 565,000 crop acres and more than 7,000 other (non-crop) acres that were protected by 5- to 25-year non-Federal levees are no longer protected with this alternative. Decreases in property values could significantly affect local economies and tax bases. Implementation costs would be high with this alternative.

Summary of Removing Agricultural Levees. Examination of the action alternatives in the Kansas City District reveals that removing agricultural levees would have had a zero to 10 percent change in the flood damage impact categories as a result of the 1993 flood event. The change in Government expenditures and reduction of risk impact categories would have been minimal. Under this alternative, the market value of floodplain real estate affected by the 1993 flood would be reduced about 20 percent. A positive aspect of levee removal is that there could have been approximately 13,000 additional acres of established forested and non-forested wetlands within the lower 500 miles of the Missouri River floodplain. It must be understood that the trade-off for this environmental benefit would be the loss of crop production. The construction cost of this alternative would be approximately $16.4 million plus significant compensation to landowners for the change in property values and the costs for acquisition of agricultural acres from willing sellers for conversion to wetlands.

(Rock Island District Discussion - "Removing all Agricultural Levees")

One alternative to reduce flood damages would be to permanently remove 419 miles of agricultural levees in 19 levee districts. The levees protect 354,000 acres from flooding on the Mississippi River and tributary streams. Permanent removal would involve degrading 2,200 100-foot sections of levee. Sections would be removed every 1,000 feet, allowing floodwaters to enter the area unimpeded.

Each lock and dam site would have to be evaluated to determine whether modifications to the Federal project would be required if all agricultural levees were removed.

The environmental option would involve purchasing 354,000 acres in fee title. Wetland plants would be established on 240,000 acres, and forest plants would be established on 80,000 acres. The remaining area would be inundated by normal river levels.

The agricultural production option would involve purchasing 354,000 acres of flood easement. The land would remain in agricultural production.

Cultural Resources. This is judged to have an extremely negative impact on historic structures in the floodplain ($^{-5}{}_{-5}....^{0}.....^{+5}$). Increased flood frequency would result in increased deterioration of structures, accompanied by accelerated rates of abandonment and demolition.

Although the impacts to archaeological sites are more varied, the consequences of permanent levee removal on these resources are judged to be strongly positive ($^{-5}.....^{0}...{}_{+4}.^{+5}$).

(St. Louis District Discussion - "Removing all Agricultural Levees")

This action alternative assumes that all Federal and non-Federal agricultural levees are removed, with urban levees left in place.

Change in Stages. The analysis of this alternative includes two sets of changes in stage depending on whether crop production is continued in the overbank flooded areas or whether overbank flooded areas have been allowed to return to "natural conditions"; e.g., trees in the overbanks.

a. No Agricultural Levees with Continued Agricultural Use. The simulation was performed with agricultural growth within the overbank area. Factors affecting conveyance were not evaluated in detail. For example, removal of the levee would not result in an effective flow width equal to the entire valley width. Physical factors such as channel meandering, vegetation, topography, structures such as roads and railroads, and other components will restrict effective flow width to a value much less than the cross section width. Various forms of land use within the overbank such as farming habitat will have considerably different roughness values. Levee removal will remove channel constraints such that channel meandering and overbank sediment deposition may actually reduce conveyance.

The systemic results for this alternative at the stream gages are displayed in the Hydraulics appendix (Appendix A). The average peak stage reduction from Lock and Dam 22 to Lock and Dam 26 is 2.2 feet, and from the St. Louis, Missouri, gage to the Cape Girardeau, Missouri, gage is 4.9 feet on the Mississippi River. The average reduction in stage on the Illinois River is 2.2 feet and on the Missouri River is 0.9 foot. The change in the hydrographs because of this alternative is shown on plates in the Hydraulics appendix. The levees removed on the Mississippi River, Illinois River and Missouri River are displayed in tables in the Hydraulics appendix.

b. No Agricultural Levees with Natural Growth. For this alternative, all agricultural levees were removed and the overbanks were replaced with natural growth. This natural growth would include a combination of woodlands, heavy vegetation, and wetlands. The systemic results for this alternative of removing levees with natural growth are displayed in tables in the Hydraulics appendix. The average peak stage increase from Lock and Dam 22 to Lock and Dam 26 is 0.1 foot, and the average stage decrease from the St. Louis, Missouri, gage to the Cape Girardeau, Missouri, gage is 0.4 foot on the Mississippi River. The average increase in stage on the Illinois River is 0.6 foot and on the Missouri River is 2.3 feet. The change in the hydrographs because of this alternative is shown in the Hydraulics appendix.

Change in Flood Damages.

a. No Agricultural Levees with Continued Agricultural Use. The difficulty in assessing this alternative is the accuracy in predicting what the agricultural setting would be without agricultural levee protection. Furthermore, the many rural farming communities may no longer continue to exist in the absence of levee protection. There may be huge social costs involved with the loss of local tax revenue to maintain adequate schools, roads and other essential services. The critical legal and institutional issues associated with this alternative appear to make it impossible to implement. An estimated $93 million decrease in economic damages (6 percent of the base condition) is associated with removing agricultural levees and assuming continued agricultural floodplain use. However, structural and other implementation costs, primarily real estate, are estimated to be $1.6 billion. In addition, there is an estimated $255 million in lost agricultural productivity.

b. No Agricultural Levees with Natural Growth. This action alternative would result in the elimination of agricultural productivity in the Mississippi River floodplain. The impacts of such an alternative would be extensive. Social costs including the basic elimination of local tax revenues and any need for schools and other public services are difficult to imagine. The 1993 agricultural flood damages would be eliminated with this alternative, at the cost of terminating the annual agricultural productivity in perpetuity.

Summary of Removing All Agricultural Levees. Examination of this action alternative in the St. Louis District is critically dependent on the assumption of what future land use would occur after removal of all Federal and non-Federal agricultural levees. Under the assumption that agricultural pursuits would continue after levee removal, the trade-off of agricultural productivity in perpetuity for environmental benefits is not as severe as the case when agricultural pursuits are terminated. In either case, the social costs and disruption to community affairs would be so significant as to seriously question the practicality of this action alternative.

<u>SETTING BACK AGRICULTURAL LEVEES</u>

The alternative of setting back all agricultural levees was evaluated as a systemic hydraulic model on the Mississippi and Missouri River main stems. The economic, environmental, and risk impacts were not evaluated for this systemic hydraulic modeling; however, brief discussions are provided in this section by the Omaha, Rock Island, and St. Louis Districts. The Omaha District has provided the results of an evaluation of this alternative on the impact study reach starting at River Mile (RM) 600.0 on the Missouri River. The Kansas City District has provided the results of an evaluation of this alternative on an impact study reach between Rulo, Nebraska, and St. Joseph, Missouri, on the Missouri River. The estimated changes in impacts from those actually experienced at the time of the 1993 flood are noted in Column M of the matrix tables at the end of this chapter.

(Omaha District Discussion - "Setting Back Agricultural Levees")

Introduction. All agricultural levees south of the urban levees at Omaha, Nebraska, and Council Bluffs, Iowa, (RM 600.0) were set back to study the systemic hydraulic effects of this alternative. Levee setback distance was set to attain a minimum flow width of 5,000 feet between the levees.

A case study was also performed to evaluate the economic, environmental and risk impacts associated with an isolated levee setback. Levees L-550 and L-536 were set back just far enough that L-550 would not have been breached, as it was in 1993. This distance was determined to be 3,000 feet.

Change in Stages. Results from the setback alternative illustrate the undesirable effect of causing downstream impacts while providing beneficial results to the local area. The levee setback starting at RM 600.0 reduced stages within the reach from Omaha to Brownville which ranged from -0.4 foot to -1.4 feet. However, at Rulo, Nebraska, there was an overall increase in stage of 1.0 foot because the levee setback altered the failure of the private levees.

Change in Flood Damages. By setting back L-550 and L-536 an additional 3,000 feet, nonfailure was accomplished in the case study model. Savings amounted to almost $13 million.

Change in Government Expenditures. Government expenditures for emergency response, disaster assistance, and FCIC and NFIP indemnities were estimated to decrease by over $13 million in the case study model. A portion of the indemnities would be prepaid by participants.

Change in Value of Floodplain Resources. Real Estate values may benefit slightly behind the levee and suffer in the newly unprotected area.

Change in Risk. The risk to people, residences, communities, and critical facilities protected by the levee would be reduced. The risk in unprotected areas and areas downstream would increase.

Change in Environmental and Cultural Resources. By setting back levees, some natural floodplain functions would be restored. Species, especially riverine fish, dependent upon periodic flooding would benefit most. There could also be a change in land use from agricultural to natural.

Implementation Costs. Construction cost for this as a non-systemic alternative was $25.8 million with partial removal of the original levee and $51.8 million for full removal.

Project cost estimates were done from a case study and were applied system-wide. The only real estate cost included was the footprint of the particular project alternative. Costs of environmental and cultural mitigation, relocation of residents or businesses, and effects on local schools, communities, and relevant taxing authorities were not quantified for project costs.

Summary. The levee setback case study illustrated that setbacks of a particular Omaha District Federal levee would have prevented overtopping of that levee during the 1993 event. However, levee setbacks were also shown to have undesirable consequences. If levee setback distance is such that the levee no longer overtops, results showed that a downstream rise in flow and stage is caused at the next river constriction. It is also possible that increased vegetative growth between the levee and river would increase roughness and offset some effects of the levee setback. In addition, negative impacts to interior drainage would include a longer outlet channel to discharge into the river, requiring increased maintenance due to siltation.

There may be significant opportunities for environmental initiatives within this alternative.

The lower cost project would cost $13 million more than the 1993 damage savings would have paid for. Without doing a site specific true cost-benefit analysis, it is impossible to accept or reject the use of levee setbacks based on this analysis. It needs to be pointed out that levee setbacks can benefit the area protected but may cause higher stages downstream.

(Kansas City District Discussion - "Setting Back Agricultural Levees")

Study Area. The effects of setting back agricultural levees were examined in a predominantly agricultural area located in the upper part of the Kansas City District between Rulo, Nebraska, and St. Joseph, Missouri. The case study area includes the left and right bank areas between approximately RM 486 and RM 454, a distance of about 32 miles. Counties in the study area include Holt and Andrew Counties in Missouri and Doniphan County in Kansas. Federal levees and one private levee in the study area were set back for the analyses. These include L476, R482, L488, L497, R500, a portion of L519-512-504, and the Windle private levee. L497 protects a portion of Forest City, Missouri, and L476 protects a portion of Amazonia, Missouri. As noted in the Environmental Resource Inventory, there are several areas of forested wetlands on the left bank of the river between river miles 474 and 466, and emergent wetlands are present near RM 467. Areas of both emergent and forested wetlands are present at the confluence of the Nodaway and Missouri Rivers, near RM 462.3.

Current Alignment. With the current study area levee alignments, approximately 37,500 acres are protected. Approximately 36,500 of these acres are estimated to be crop acres. The remaining 1,000 acres include portions of Forest City and Amazonia, Missouri, railroads, State highway, and some timbered areas. About 6,200 acres are riverward of the current alignment, and an estimated 50 percent of these are assumed to be farmed. During the 1993 flood, three of the Federal levees - R500, L488 and R482 - were overtopped. The remaining Federal levees, L504, L497 and L476, had 1 to 3 feet of freeboard remaining at the 1993 peak discharge. The 6,200 acres riverward and about 20,000 acres landward of the levees were flooded in 1993. Of these, an estimated 22,800 were crop acres, with 1993 agricultural crop damages of about $5.7 million in the study area.

Setback Alignment. For this analysis, levees were set back one and a half times the existing floodway width, or a minimum of 5,000 feet, whichever was greater. Tops of levee remained the same as for the current alignment. With the levee setback, nearly 6,200 additional acres would now be located riverward of the alignment and have no protection from flooding. If this setback alignment had been in place during the 1993 flood, the private levee would still have overtopped; however, none of the Federal levees in the study area would have overtopped.

Change in 1993 Flood Stages. Setting back the levees in the study area would decrease the 1993 flood stage in the St. Joseph reach by less than one-tenth of a foot. In the Kansas City reach, there would be no change in the 1993 flood stage.

Change in Flood Damage Impacts. Total study area acres flooded with this alternative would be approximately 22,000, a reduction of about 4,200 acres. About 9,500 of these flooded acres are landward of the private levee with this setback alignment.

Assuming no change in current land use, an estimated 18,700 of the flooded acres are crop acres, and 1993 agricultural crop damages in the study area would have been about $4.7 million with the setback alignment. This would be a reduction of $1 million or about 18 percent from the 1993 current alignment crop damages in the study area. Other Rural impacts would also be expected to decrease. No change would be expected in the remaining categories for the study area.

If it is assumed that only about 50 percent of the formerly protected crop acres that are now riverward of the setback alignment will be farmed, and the rest will revert back to "natural conditions," crop damages would be decreased about $1.8 million, or nearly 32 percent.

Change in Government Expenditures. Based on the decrease in crop acres flooded, decreases in the Disaster Relief-Agriculture and FCIC payments would also be expected.

Change in Value of Floodplain Resources. Approximately 620 crop acres formerly protected to about the 10-year event by the private levee, and about 5,560 crop acres formerly protected by Federal agricultural levees to about the 100-year event, would be located riverward of the setback alignment and no longer protected. The decrease in the market value of land for the affected acres in the study area could be about 35 to 40 percent overall, assuming no change in land use.

Assuming a change in land use for the crop acres now riverward of the levee and no longer protected, nearly 3,100 crop acres, or nearly 8 percent of total crop acres in the study area, would be removed from agricultural production. Net agricultural production would be significantly reduced. This loss would be somewhat offset by the value of use of the land for environmental purposes.

Change in Risk. No change in these categories would be expected for the study area.

Other Implementation Costs. Compensation to landowners of the nearly 6,200 acres now located riverward of the setback alignment and that would have no flood protection could be required based on the resulting decline in market value of land. If it is assumed some cropland would revert to "natural conditions," purchase of these acres from willing sellers would be required. Under both assumptions, the local economy and tax base would be adversely affected.

Summary of Levee Setback in Case Study Area. The decrease in crop damages with levee setback is due to the net overall decrease in crop acres flooded. Although there is an increase in acres flooded riverward of the levee, there is a larger decrease in acres flooded landward of the setback alignment. Three Federal levees that overtopped in 1993 are not overtopped with the levee setback alternative. Changes in the 1993 flood stages and other hydrologic changes are negligible with this alternative.

(Rock Island District Discussion - "Setting Back Agricultural Levees")

The levee setback alternative explores the benefits of stage reduction by increasing the area available for flood conveyance. The plan would require the removal and setback of 207 miles of levee. The distance between left and right bank levees was increased by 50 percent. The distance between left and right bank levees typically ranges from 4,000 to 14,000 feet. A 50 percent increase would widen the distance between levees ranging from 6,000 feet to 21,000 feet. The average setback distance is 1,600 feet. Typical setback distances are shown in Table 9-3.

Cultural Resources. Impacts to historic structures from setting back the levees would be overwhelmingly negative for those structures left riverward of the levee. For those still protected, the results of reduced levee overtopping would be positive. Overall, this alternative is judged to have a solidly negative impact on historic structures $(^{-5}..._{-3}..^{0}.....^{+5})$.

The most overwhelming and immediate impact of levee setbacks would be the damage sustained from construction of the new levees.

Even if the need for borrow could be reduced by using the existing levees, soil disturbance within the new construction right-of-way would be extensive and generally would have greater archaeological impacts than those within the original levee right-of-way. This is because landforms farther back from the present channel generally have a greater potential for containing archaeological sites than those near the channel. Overall, the effects of levee setbacks are judged to be solidly negative for archaeological resources $(^{-5}.._{-3}..^{0}.....^{+5})$.

__(St. Louis District Discussion "Setting Back Agricultural Levees")__

Background. St. Louis District did not specifically identify values for inclusion in the matrix table in this Floodplain Management Assessment for "Setting Back Agricultural Levees" because extensive economic and environmental assessments were not pursued for this action alternative. However, some hydraulics and hydrology analysis was accomplished for two alternative conditions.

Change in stages. Agricultural levees on the Missouri and Mississippi Rivers were set back from their existing levee alignments. These levee setbacks were established at 150 percent of the existing floodway, or to provide a minimum floodway of 5,000 feet, whichever is greater. Two alternative conditions were considered as follows:

1. Levee Setbacks, Existing Levee Height. This alternative examined the effect of levee setbacks on flow conditions with the setback levee height at the existing levee height. The systemic results for this levee setback alternative are displayed in Appendix A. The average peak stage decrease from Lock and Dam 22 to the Cape Girardeau, Missouri, gage was 1.1 feet on the Mississippi River. The average decrease in stage on the Illinois River was 0.8 foot, with an average <u>increase</u> in stage on the Missouri River of 0.9 foot. The changes in the hydrographs because of this alternative and the performance of the levees and percent of change from the computed base and alternative peak discharge for each gage site are shown in Appendix A.

2. Levee Setbacks, No Overtopping. Agricultural levees only on the Mississippi River were set back and examined for this alternative. The setback distances are as described in 1. above. This alternative assumed that the new setback levees would not be overtopped but would be sized to contain the 1993 flood. The systemic results for this levee setback alternative are presented in Appendix A, as are the change in the hydrographs, performance of the levees and percent of change from the computed base, and alternative peak discharge for each gage site.

Change in damages. The economic and environmental impacts of the two levee setback alternatives discussed for the St. Louis District were not analyzed. It is considered that these impacts would be similar but less severe than those identified for the levee removal alternative and largely dependent upon the land use assumed to occur in the setback area.

Summary of Levee Setbacks. Examination of this action alternative in the St. Louis District was limited to just the hydraulic and hydrology impacts as summarized above and detailed in Appendix A.

Table 9-3
Floodplain Management Assessment
Typical Levee Setback Distances
Mississippi River Agricultural Levees
Muscatine, Iowa, to Hannibal, Missouri

Levee District	Average Levee Setback (Feet)
Muscatine Island Levee District	1,300
Drury Drainage District	1,000
Bay Island Drainage and Levee District No. 1 and Subdistrict No. 1 of Drainage Union No. 1	1,200
Iowa River-Flint Creek Levee District No. 16	1,800
Henderson County Drainage District No. 3	1,700
Henderson County Drainage District No. 1	1,700
Henderson County Drainage District No. 2	1,700
Green Bay Levee District No. 2	1,700
Des Moines-Mississippi Levee District No. 1	1,000
Mississippi Fox Drainage and Levee District No. 2	3,400
Gregory Drainage District	1,200
Hunt and Lima Lake Drainage District	1,200
Indian Grave Drainage District	3,100
Union Township Drainage District	1,700
Fabius River Drainage District	1,500
Marion County Drainage District	1,700
South River Drainage District	1,200
South Quincy Drainage and Levee District	1,500
Sny Island Levee and Drainage District	2,200

ESTABLISHING UNIFORM AGRICULTURAL LEVEES (25-YEAR FREQUENCY)

The alternative of establishing a uniform height of all agricultural levees was evaluated as a systemic hydraulic model on the Mississippi and Missouri River main stems. An evaluation of this alternative is provided by the Omaha, Kansas City, Rock Island, and St. Louis Districts. The 25-year level of protection is not intended to recommend that level as being the most likely for implementation, but rather a level that was considered to be representative for evaluation purposes. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Column N of the matrix tables at the end of this chapter. **(Omaha District Discussion - "Establishing Uniform 25-year Levees")**

Introduction. For this alternative, the height of agricultural levees along the Missouri River was set to provide a uniform 25-year level of protection. Levees above the 25-year level were notched and levees below the 25-year level were raised.

Change in Stages. The alternative produced a reduction in peak stage which varied from -1 foot to -3 feet and a discharge reduction of -10,000 to -60,000 cfs. These reductions were possible as a result of the failure of 10 additional levee cells and the flooding of a significant area between Omaha, Nebraska and Rulo, Nebraska. At St. Joseph, Missouri, the farthest downstream point employed for comparing results, stage and discharge reductions for this alternative exceeded reductions computed for the levee removal alternative.

Change in Flood Damages. Total damage would have been increased by nearly $20 million as levees farther upstream, that had not been overtopped, now were.

Change in Government Expenditures. Government expenditures for emergency response, disaster assistance, and FCIC and NFIP indemnities were estimated to increase by more than $15 million. A portion of the indemnities would be prepaid by participants.

Change in Value of Floodplain Resources. Real estate values could be expected to drop in the areas of decreased protection and increase in the areas of improved protection, depending on people's perceptions. Estimating the total change in value of floodplain resources is beyond the scope of this assessment and requires an analysis of annualized costs and benefits. This is discussed in the section on sensitivity of results at the end of this chapter.

Change in Risk. Several small towns, railroads, highways (including I-29), and critical facilities would be more vulnerable to flooding, as would a very large number of acres of extremely good cropland.

Change in Environmental and Cultural Resources. The environmental benefits from a uniform height 25-year levee would not be much different, in the long run, from the base condition. Where more frequent overtopping of levees and subsequent ponding behind the levees occurred, there would be a benefit to migrating waterfowl attracted to the flooded cropland to feed on the rich supply of seeds and invertebrates. Where less frequent flooding occurred, the opposite would be true. Overall, the effect would not be great one way or the other.

Cultural resources also would not be greatly affected, overall.

Implementation Costs. Project costs were estimated at just over $32 million. Project cost estimates were done from a case study and applied system-wide. The only real estate cost included was the footprint of the particular project alternative. Costs of environmental and cultural mitigation, relocation of residents or businesses, and effects on local schools, communities, and relevant taxing authorities were not quantified for project costs.

Summary. The net effect in Omaha District in 1993 would have been considerably more flooding. Benefits of this alternative would come to those farther downstream who get lower stages because of the detention effect of these levees. From a National Economic Development (NED) perspective, this idea may or may not be desirable on a case-by-case basis. Practically speaking, it would be difficult to implement such a system.

(Kansas City District - "Establishing Uniform 25-year Levees")

Change in Stages. This alternative would reduce 1993 flood stages in all five reaches from 0.3 foot to 5.0 feet. The largest decreases would occur in the St. Joseph (-5 feet) and Kansas City (-4.5 feet) reaches. The Waverly, Boonville and Hermann reaches would have decreases of less than 1 foot.

Change in Flood Damages. Providing uniform levee heights (25-year) may reduce Residential flood damages an estimated 4 percent and Other Urban flood damages by about 7 percent. Approximately seven communities may no longer flood due to reduced stages with this alternative. However an estimated three new communities would be flooded, because agricultural levees that did not overtop in 1993 would now overtop with this alternative. Other communities would still flood, but damages are assumed to be lower because stages are lower.

Agricultural and Other Rural damages are estimated to decrease by about 20 percent. This estimate is based on an overall decrease of about 151,000 crop acres flooded due to stage reductions and fewer agricultural levees overtopped with this alternative.

Change in Government Expenditures. Emergency response costs are expected to decrease overall because of reduced stages and decreased floodfight costs. A low decrease would be expected in agricultural disaster relief costs based on the decrease in crop damages with this alternative. Disaster relief costs related to human resources could be expected to experience a low decrease based on the estimated decreases in Residential and Other Urban damages. NFIP payments may not change or may experience some decrease with this alternative. If agricultural levees are notched, some additional people protected by Federal agricultural levees may buy flood insurance. However, this increase would probably not offset the potential decrease in NFIP payments due to decreases in Residential and Other Urban damages. Crop damages are decreased with this alternative, but more crop acres behind Federal agricultural levees may be insured with this alternative. No change or a low decrease in FCIC payments could be expected.

Change in Value of Floodplain Resources. With this alternative, land values would decrease for approximately 127,000 crop acres that formerly had 100-year protection from Federal agricultural levees and now have only 25-year protection. Land values would increase for some 431,000 crop acres that, although still flooded, would have the level of protection increased from 10-year or less to the 25-year level. The estimated change in the Net Agricultural Production category could be about a 4-percent increase overall for the acres affected with this alternative.

About 5,200 other (non-crop) acres protected by Federal agricultural levees would have a decrease from 100-year to 25-year protection and thus decreased land values. This decrease could be offset by increases in land values for communities that would no longer flood or would have greatly reduced levels of flooding because of reduced stages under this alternative. Based on analytical judgment, the overall net change in the Urban Land Value category could be insignificant.

Change in Risk. The change in critical facilities at risk is expected to be insignificant with this alternative. Number of people vulnerable would be expected to decrease somewhat based on the decreases in Residential and Other Urban damages. Communities vulnerable would decrease slightly (about a 3 percent decrease in number of communities flooded) under this alternative. Residential structures vulnerable are estimated to decrease by about 5 percent based on estimates of structures in communities no longer expected to flood, and rough estimates of additional structures flooded in new communities subject to flooding.

Other Implementation Costs. Compensation to landowners of acres protected by Federal agricultural levees that now offer only 25-year protection with this alternative could be required based on the resulting decline in property values. Local economies and tax bases potentially could be somewhat affected due to reduced property values in these areas. The implementation cost is estimated to be relatively low.

Summary of Uniform 25-Year Height for Agricultural Levees. The alternative of having a uniform 25-year level of protection for agricultural levees would have reduced damages approximately 20 percent in the agricultural sector, with modest reductions in urban damages. The changes in Government expenditures, value of floodplain real estate, and reduction of risk would have experienced low to modest changes. Environmental impacts for the floodplain would have been associated mainly with construction activities. The cost of this alternative is $340 million plus lands, easements, rights-of-way, relocations, and disposal areas.

(Rock Island District - "Establishing Uniform 25-year Levees")

The 25-year uniform height alternative involves constructing overflow sections in each agricultural levee at a predetermined elevation. Ideally, an overflow section would be set in the downstream end of a levee. In the event of overtopping, floodwater would back into the protected area at a low, damage-minimizing velocity.

Levee overtopping damages could be reduced by construction of overflow weirs in agricultural levees. By controlling overtopping in the least damaging method possible, there would be a reduction or elimination of repair costs and land restoration costs associated with levee breaches.

The installation of an overflow weir would eliminate the need for floodfight levee raises. Overtopping at the predetermined 25-year level would be planned and accepted by involved parties. The State or Federal Government would maintain an interest in the overtopping elevation to prevent unauthorized floodfighting activities.

Cultural Resources. This is judged to have a very negative impact on historic structures in the floodplain ($^{-5}{}_{\cdot\cdot-4}\cdots{}^{0}\cdots\cdots{}^{+5}$). Increased flood frequency would result in increased deterioration of structures, accompanied by accelerated rates of abandonment and demolition second only to that of complete levee removal.

None of the positive effects for archaeological sites that were seen with complete levee removal are predicted here. Little agricultural abandonment would occur in the levee districts, and only minor amounts of sediment would offset agricultural erosion. The negative impacts would be limited mainly to the establishment and maintenance of the overflow weirs. Overall, the impacts to archaeological sites are judged as slightly negative compared to the existing operation of the levee system ($^{-5}\cdots{}_{-1}{}^{0}\cdots\cdots{}^{+5}$).

(St. Louis District Discussion - "Establishing Uniform 25-year Levees")

This alternative would have all agricultural levees designed to overtop at the 25-year flood height. Essentially, this action would use the storage behind the levees to minimize the flood impacts on unprotected areas and urban levees.

Stage Impacts. For this alternative, the height of all agricultural levees was set to correspond with a 4 percent annual chance (25-year) flood. Federal levees, which are currently higher than the 25-year elevation, were notched to an elevation equal to the 25-year elevation at the downstream end of the levee. Levees lower than the 25-year elevation were raised to the 25-year elevation plus 3 feet with a notch at the downstream end of the levee at the 25-year elevation. When flood levels exceed the 25-year level, the levee notch is eroded and the cell fills with water. In this manner, the levee cells along the channel act as detention basins to store flows which exceed the 25-year event. The systemic results for this 25-year levee alternative are displayed in tables in the Hydraulics appendix (Appendix A). The average peak stage decrease from Lock and Dam 22 to the Cape Girardeau, Missouri, gage is 3.6 feet on the Mississippi River. The average decrease in stage on the Illinois River is 3.3 feet and on the Missouri River is 1.6 feet. The change in the hydrographs because of this alternative is shown on plates in the Hydraulics appendix. All levees modeled were set to the 25-year level and are displayed in a table in the Hydraulics appendix.

Economic and social impacts. All agricultural levees would have a controlled overtopping at the 25-year flood level. All cells reflect increases from the base condition due to inundation of levee areas that did not overtop.

There would be some decrease in unprotected areas due to reduced stages caused by additional storage in levee areas. While this action shows a net increase of $187 million in economic damages, it is difficult to predict the behavioral attitudes that would accompany the alternative. This action would also entail substantial legal and institutional difficulties.

Summary of St. Louis District 25-year agricultural protection. Within the St. Louis District area, the existing Federal agricultural flood protection provides uniform 50-year flood protection. Thus, this action alternative would require degrading the flood protection that has been in place and has worked successfully for many years. The concept of uniformity in agricultural flood protection has merit based on the experience regarding 50-year flood protection within the St. Louis District area. Floodfighting efforts are more consistent and predictable when dealing with uniformly designed levee protection. Greater uniformity in the operation and regular maintenance of the agricultural flood protection would also be an asset. The possibility of reducing the level of existing agricultural flood protection appears to be fundamentally impractical.

RAISING LEVEES ABOVE THE 1993 FLOOD LEVELS

The alternative of raising levees above the 1993 flood levels and stabilizing them to prevent breaching was evaluated as a systemic hydraulic model on the Mississippi and Missouri River main stems. A discussion of this systemic evaluation of this alternative is provided by the Omaha, Kansas City, Rock Island, and St. Louis Districts. St. Louis has provided a separate evaluation of raising levees between the mouth of the Missouri River and Cairo, Illinois, to the Standard Project Flood elevation, which is higher than the 1993 flood levels and would generally be equal to the level of protection provided for the lower Mississippi River under the Mississippi River and Tributaries Project. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Column O of the matrix tables at the end of this chapter.

(Omaha District Discussion - "Raising Levees Above 1993 Flood Levels")

Introduction. For this alternative, all agricultural and urban levees were raised so no breaching or overtopping of any levees would occur during the simulated 1993 flood. Levee locations or roughness values were not altered for this alternative.

Change in Stages. No changes were observed from the base condition except in the reaches downstream of Brownville, Nebraska. These results are consistent with the fact that no Federal levees overtopped or failed in the reach from Omaha, Nebraska, to just upstream of Brownville, Nebraska. In the Federal levee area downstream of Brownville, Nebraska, stage increases were minor and averaged near +1 foot. In the Rulo, Nebraska, area, where severe private levee damage occurred and the flow width varied from 3 to 7 miles for the 1993 event, confining the flow to a narrow leveed width caused a large stage increase of nearly +8 feet.

Change in Flood Damages. The levee raise to full confinement alternative saved over $21 million in the model results.

Change in Government Expenditures. Government expenditures for emergency response, disaster assistance, and FCIC and NFIP indemnities were estimated to decrease by over $22 million. A portion of the indemnities would be prepaid by participants.

Change in Value of Floodplain Resources. Real estate values could be expected to benefit substantially and people and infrastructure overall would be better off. But these savings in damages might be limited by interior ponding behind the levees.

Change in Risk. The number of people, residences, communities, and critical facilities vulnerable to flooding would be greatly reduced.

Change in Environmental and Cultural Resources. The only environmental benefit resulting from a fully confined flood protection level would be the increased potential for ponding behind the levee, which results in temporary wetlands.

Cultural resources may be affected by the footprint of the levee or the location of the borrow pit, but would generally benefit from the added flood protection.

Implementation Costs. Project costs were estimated at over $84 million. Project cost estimates were done from a case study and applied system-wide. The only real estate cost included was the footprint of the particular project alternative. Costs of environmental and cultural mitigation were not quantified for project costs.

Summary. Damage reduction would come partly at the expense of those downstream. A frequency based cost-benefit analysis is required to determine the most desirable option in a potential site area.

(Kansas City District Discussion - "Raising Levees above 1993 Flood Levels")

This action alternative assumes that existing agricultural levees are raised high enough to contain the 1993 flood, and acres protected by these levees would not be damaged if the 1993 flood event would again occur.

Change in Stages. Raising agricultural levees to contain the 1993 flood would raise 1993 flood stages in all five reaches by 1.6 feet to 6.9 feet. The largest increases in stage occur in the reaches downstream from Kansas City.

Change in Flood Damages. Residential damages would be decreased by slightly more than 50 percent overall. Other Urban damages would decrease by 75 percent to 90 percent, depending on whether certain critical facilities are also protected with this alternative. Communities behind agricultural levees would no longer flood; however, more than 40 communities are still unprotected and could experience much higher damages because of the higher stages with this alternative. Communities that were damaged in 1993 due to flooding from tributaries and streams other than the Missouri River would also still be damaged.

With this alternative, some urban levees would also have to be raised to contain the higher flood stages and avoid induced damages in urban areas behind these levees. One urban levee in the St. Joseph reach, three urban levees in the Kansas City reach, and one urban levee in the Hermann reach would have to be raised.

Agricultural and Other Rural damages would be decreased by 80 percent overall. Although crop acres flooded by the Missouri River would be significantly decreased with this alternative, crop damages would still occur on crop acres farmed riverward of levees and on crop acres flooded by other tributaries and streams.

Change in Government Expenditures. Emergency costs would decrease in areas not now subject to flood damage, but would increase in those areas that would experience higher levels of flooding. It is estimated that the net change would be some decrease overall. Based on the major decreases in Residential, Other Urban, Agricultural and Other Rural damages with this alternative, disaster relief expenditures related to human services and agriculture would also be expected to decrease significantly. If levees are raised, fewer people may buy flood insurance in those areas behind the levees; however in those areas with no protection and increased flood stages, more people could be expected to buy flood insurance. It is assumed that the substantial decrease in damages in protected areas might offset any additional damages in unprotected areas, resulting in at least some decrease overall in NFIP payments.

Change in Value of Floodplain Resources. With this alternative, the market value of land would increase significantly. Crop acres which had 100-year protection from Federal agricultural levees (about 127,000 acres) would now be protected from the 1993 flood. Crop acres with 5- to 25-year protection from non-Federal agricultural levees (about 565,000 acres) would also now be protected from the 1993 flood. However, about 16,000 acres would be required to construct the levees and would be removed from crop production. The net overall increase for acres affected is an estimated 30 percent in the Net Agricultural Product category.

More than 40 communities may experience much higher levels of flooding with this alternative and would experience decreases in property values. This decrease is offset by increases in value for the nearly 5,200 non-crop acres that had 100-year protection and the more than 7,000 non-crop acres that had 5- to 25-year protection, all of which would now be protected from the 1993 flood. Based on analytical judgment, however, an overall decrease in the Net Urban Real Estate Value category might be expected with this alternative.

Change in Risk. The number of critical facilities with harmful releases could decrease or remain the same depending on whether they would be protected from the 1993 flood when levees are raised. There is insufficient information available to make a more specific estimate of change.

An estimated low to moderate decrease could occur in the number of other critical facilities that would still be damaged with this alternative. Essential and emergency services facilities like Federal post offices, fire stations, and schools, located in communities now protected under this alternative, are the basis for the estimated decrease.

A moderate to high decrease in number of people vulnerable might be expected because of the high levels of protection provided by the raised levees. This could be offset by the increased number of people in communities still subject to flooding at higher stages with this alternative.

The number of communities vulnerable could be expected to decrease by 20 to 70 percent. About 80 communities received NFIP payments for the 1993 flood, but it is unknown whether these payments were made for actual flood damage or for a number of other reasons such as backed-up sewers. If these communities no longer experience these types of damages with this alternative, then the decrease in number of communities vulnerable could be expected to approach 70 percent.

Residential structures vulnerable would also be expected to decrease an estimated 50 percent or more.

Other Implementation Costs. Communities not protected under this alternative and subject to even higher levels of flooding could experience severe economic impacts. Costs to provide protection to these communities or relocate damageable development out of the floodplain could be moderate to significant.

Summary of Raising Levees to Prevent Overtopping. Raising levees and floodwalls to protect against the 1993 flood would have significantly reduced damages in both the urban and agricultural sectors and would have reduced the critical facilities and communities at risk. This alternative would also increase the market value of agricultural property, while possibly decreasing the value of urban real estate, because unprotected communities would be subject to higher levels of flooding. Additionally, there would have been a substantial reduction in government expenditures for disaster relief. Environmental impacts for the floodplain would have been associated mainly with construction activities. The cost of this action alternative would easily exceed $2.5 billion in the Kansas City District.

(Rock Island District Discussion - "Raising Levees above 1993 Flood Levels")

Agricultural levees raised to the relatively high 500-year level would offer protection from most floods. The likelihood of a levee being overtopped would be reduced to a very slight risk. Agricultural levees, in many cases, typically are designed to protect against the 50-year flood, with 3 feet of freeboard.

Cultural Resources. Reduced flood damages would have a very positive effect on historic structures in the floodplain. Increases in agricultural, residential, and commercial development would negatively affect historic structures. Overall, the effect of this alternative on structures is judged to be quite positive ($^{-5}.....^{0}..._{+4}.^{+5}$).

Overall, impacts to archaeological sites from this alternative are judged to be moderately negative ($^{-5}..._{-2}.^{0}.....^{+5}$).

(St. Louis District Discussion - "Raising Levees above 1993 Flood Levels")

This action alternative would raise 25 agricultural levees in the St. Louis District to withstand the 1993 flood.

Change in Stages. For this action alternative, all agricultural and urban levees were raised so no breaching or overtopping of any levees would occur during the simulated 1993 flood. Levee locations or roughness values were not altered for this alternative. The systemic results for this alternative of containing the 1993 flood are displayed in the detailed hydraulics tables. The average peak stage increase from Lock and Dam 22 to Lock and Dam 26 is 4.4 feet, and from the St. Louis, Missouri, gage to the Cape Girardeau, Missouri, gage is 6.6 feet on the Mississippi River. The average increase in stage on the Illinois River is 5.4 feet and on the Missouri River is 5.2 feet. The change in the hydrographs because of this alternative is shown on plates in the Hydraulics appendix (Appendix A). The levees raised to contain the 1993 flood are displayed in the Hydraulics appendix.

Change in Damages. Twenty-seven levees that failed in 1993 would be raised to prevent overtopping. All decreases reflect net impacts in unprotected versus protected areas. A net reduction of $365 million (22 percent of the base condition) in economic damages is estimated from this action. However, implementation costs are estimated to be $6.1 billion. While there is an estimated net reduction in damages, this alternative would cause significantly increased flooding in unprotected areas.

(St. Louis District Special Study - "Raising Levees to Higher MR&T Levels")

Background. This special impact study action alternative would raise all Federal levees in that portion of the St. Louis District from the mouth of the Missouri River to Cairo, Illinois, to the Standard Project Flood (SPF) elevation. This height of levee is significantly higher than 1993 flood elevations and would generally be equal to the level of flood protection provided for the lower Mississippi River under authority of the Mississippi River Commission (MRC) via the Mississippi River and Tributaries Project (MR&T). This analysis was not a systemic floodplain assessment study, but as mentioned previously, focused only on that portion of the St. Louis District from the mouth of the Missouri River to Cairo, Illinois.

The Congressionally authorized flood control project for the lower Mississippi River and Tributaries is designed to contain the "project flood" from Cairo, Illinois, to New Orleans, Louisiana. This MR&T design flood is defined as the greatest flood having a reasonable probability of occurrence, without denoting a specific design frequency. This special study evaluates a similar system from Cairo, Illinois, to the mouth of the Missouri River. The design of the "project flood" was reviewed in the 1950's. Some 35 different hypothetical combinations of historical storms were sequentially arranged to conform with frontal movements and synoptic situations consistent with those in nature, to determine the meteorologically feasible pattern that would produce the greatest runoff in the lower Mississippi River. This extensive analysis for the lower Mississippi River was not performed for the middle Mississippi River reach (Cairo, Illinois, to the mouth of the Missouri River at St. Louis, Missouri) for this assessment. The design for the middle Mississippi River was accomplished using the established "urban design flood."

The "urban design flood" is defined as a discharge of 1,300,000 cfs at St. Louis, Mis-souri, adjusted for additional discharge from the drainage area downstream of St. Louis, to a discharge of 1,460,000 cfs at Cairo, Illinois (Mississippi River flow only). At the time the urban levees were designed, this was considered to be the approximate discharge of the 1844 flood. Current frequency studies estimate that this discharge is at least a 0.2 percent annual chance (500-year) flood. The observed discharge hydrographs of the 1993 flood were adjusted upward to obtain a possible urban design discharge hydrograph and routed with UNET. The resultant elevations represent the height of the levees needed from St. Louis, Missouri, to Cairo, Illinois, to contain the "urban design flood." For the Floodplain Management Assessment analysis, the "urban design flood" for the middle Mississippi River was considered to be similar to the "project flood" for the lower Mississippi River. The required levee heights were adjusted to account for various hydrologic uncertainties.

Change in Stages. The flood elevation impacts of containing this design flood between levees extending from St. Louis, Missouri, to Cairo, Illinois, are significant. For example: a. At the St. Louis gage (RM 179.6), the existing urban height flood protection levee would have to be raised about 5 feet; b. For Bois Brule Drainage and Levee District (RM 95.0-109.5), an agricultural design levee, the average levee height raise would be 11 feet; c. At the Cape Girardeau, Missouri, gage (RM 52.0), the urban protection levee and floodwall would have to be raised about 5 feet to contain a flood of similar magnitude used for the design of the lower Mississippi River flood protection design.

Change in damages. Raising levees to contain the "urban design flood" within the St. Louis District would result in increased peak flows in the middle Mississippi River and could affect flood stages up to and including the MR&T Project flood level in the vicinity of Cairo, Illinois. The evaluation of these potential impacts is complex and beyond the scope of this analysis. However, any future studies that consider changes in the present middle Mississippi River levee system should include the evaluation of these downstream effects.

Under this alternative, all existing Federal levees would provide Standard Project Flood (SPF) protection. All cell entries reflect a net change of reduced flood damage in protected areas and increased flood damage in unprotected areas. From an environmental perspective, this alternative was not addressed systemically within the St. Louis District study area or by river reach; St. Louis District hydrologic and hydraulic modeling of this alternative allowed for estimation of percent of floodplain inundated; other environmental impact categories were not evaluated.

500-YEAR PROTECTION FOR URBAN AREAS

The alternative of providing a minimum of 500-year level of flood protection for urban areas was not evaluated systemically. However, the Kansas City, Rock Island, St. Paul, and St. Louis Districts have provided separate evaluations of this alternative. The Kansas City District provides an evaluation of an urban area on the Missouri River 5 miles upstream from downtown Kansas City. The St. Paul District provides an evaluation of a reach of the Minnesota River. The Rock Island District provides an evaluation of two urban areas in the vicinity of Des Moines and West Des Moines, Iowa. The St. Louis District provides an evaluation of two impact study reaches, the Chesterfield-Monarch area on the Missouri River and the River Des Peres area near the city of St. Louis. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Column P of the matrix tables at the end of this chapter.

(Kansas City District Discussion - "500-year Protection for Urban Areas")

In a recent previous study funded through traditional General Investigation appropriations, the Kansas City District analyzed 500-year level of levee protection for an urban area including the economic, environmental, and social impacts of providing 500-year protection. For the Floodplain Management Assessment, we reevaluated the findings of that previous analysis using the 1993 flood as a base condition.

Study Area. The urban area we analyzed is along the Missouri River 5 miles upstream of downtown Kansas City between RM 371.4 and RM 376.5. The area, known locally as L-385, includes portions of the cities of Riverside, Northmoor, and Kansas City, Mis-souri.

This area presents characteristics desirable for future industrial activities. It is the only area of significant size ready for industrial development close to the heavily urbanized portions of Kansas City, Kansas, and Kansas City, Missouri. About 835 acres could be developed after the addition of 100-year or greater flood protection. Developers have filled or are filling nearly all of the floodplain that can be economically filled to meet National Flood Insurance Program regulations. Filling some of the area is not presently cost effective, but development of those areas would be possible with flood protection.

The area is near both north-south and east-west Interstate highways, and is only minutes by road from both a cargo airport and a major metropolitan passenger airport. It has a commercial barge dock on the Missouri River and a Class I railroad. In addition to its excellent transportation features, the project area's other infrastructure development includes water, sewer, power, and gas utilities adequate to serve most modern industrial facilities.

Economic Investment. Investment in the study area consists of residential; commercial, which includes manufacturing, wholesaling, retailing, and commercial services; and public, which consists of utilities, transportation facilities, and other public facilities and services. Table 9-4 summarizes the value of urban floodplain improvements and the average annual damages in the study area by investment cate-gory.

Table 9-4
Floodplain Management Assessment
Value of Floodplain Improvements and the
Average Annual Damages by Investment Category

INVESTMENT CATEGORY	INVESTMENT (1994 DOLLARS) ($000)	AVERAGE ANNUAL DAMAGES $(000)
COMMERCIAL	$301,098.00	$3,705.20
RESIDENTIAL	$5,112.00	$94.90
PUBLIC	$17,275.10	$331.00
TOTAL	$323,485.10	$4,131.10

Alternative Analysis. In the prior study, we analyzed levee plans that would provide 100-year and Urban Design Flood (UDF)(500-year) protection. The 100-year level of protection and the UDF level of protection both achieved a benefit-cost ratio greater than 1. The UDF levee was superior to the 100-year levee for the following reasons:

- the benefit-cost ratio for 100-year protection was slightly lower than the benefit-cost ratio for UDF protection;

- the net benefits for 100-year protection were slightly lower than the net benefits of UDF protection;

- impacts for UDF protection would not increase significantly compared to the impacts of 100-year protection;

- UDF protection would reduce the chance of catastrophic failure which could have severe consequences in view of the significant commercial and industrial development in the area (the 1993 flood, which caused approximately $111,100,000 in damages in this area, would have exceeded the 100-year levee by about 2 feet); and

- UDF protection would be consistent with the protection provided for the adjacent downstream unit (North Kansas City Levee) and the unit on the opposite bank of the Missouri River (Fairfax Levee).

The evaluated plan is a levee 6.15 miles long, plus 1,900 feet of floodwall, 0.5 mile of channel improvements on the Line Creek tributary, six drainage structures, five closure structures, one sandbag gap, one stop log gap, two pumping plants, three road raises, and one bridge removal. The project would protect approximately 1,586 acres. The main stem levee would protect against UDF floods on the Missouri River. The design discharge is 460,000 cfs. Project costs are summarized in Table 9-5.

Table 9-5
Floodplain Management Assessment
Project Costs

ITEM	EXPENDITURE ($000)
Planning, Engineering, and Design (PED)	$ 6,160.0
Lands, Easements, Rights-of-Way, Relocations, and Disposal Areas (LERRD)	$ 4,546.0
Construction	$36,738.0
SUBTOTAL	$47,444.0
Interest During Construction (IDC)	$10,545.4
TOTAL	$57,989.40

Benefit-Cost Analysis. The annual cost and annual capitalized benefits (including $1,667,600 in location benefits) of the recommended plan are summarized in Table 9-6.

Table 9-6
Floodplain Management Assessment
Annual Benefits and Costs

ANNUAL BENEFITS AND COSTS	
Price level: October 1994 Interest rate: 8.00 percent	
ANNUAL BENEFITS	$6,006,300
ANNUAL COSTS	$4,681,300
BENEFIT-COST RATIO	1.3
NET BENEFITS	$1,325,000
RESIDUAL DAMAGES	$253,900

Hydraulic Impacts of Levee. The floodway averages about 2,500 feet throughout the Kansas City reach of the Missouri River. Two bridges in the L-385 reach have openings of 2,100 feet and 1,600 feet and control the floodway width. Some segments of the levee alignment are on the floodway edge and other segments are substantially landward of the floodway edge. The levee alignment generally follows an 800- to 1,000-foot setback from the edge of the Missouri River.

Project impacts to the water surface along the Missouri River are small. A maximum rise of 0.3 foot occurs in the 100-year flood profile at river mile 375.66. The UDF increase is 0.6 foot at the upstream end of the levee.

1993 Flood Impacts.

a. Economic Impacts. The 1993 flood caused approximately $111,100,000 in flood damages to the L-385 area, including $100,000 in residential damages and $111,000,000 in commercial, industrial, and public damages. A 500-year levee would have prevented all of these damages. Agricultural and other rural damages of more than $250,000 would have been prevented by the proposed levee. The 1993 flood would have overtopped the 100-year levee by about 2 feet.

Government expenditures in the area during the flood included approximately $270,000 for emergency response, $100,000 in agricultural disaster relief, $100,000 for human resources disaster relief (buyouts and mitigation), $6,467,000 in National Flood Insurance Program payments, and $26,000 in crop insurance payments. All of these expenditures could have been avoided if the area had been protected with a 500-year levee.

Providing 500-year flood protection for the L-385 area would allow commercial and industrial development of 835 acres in the Kansas City metropolitan area. With flood protection, we estimate real estate value of this floodplain acreage would increase $21,600 per acre or a total of $18,036,000 ($1,667,600 annual capitalized benefits at 8 percent interest).

Agricultural lands lost as a result of construction of the levee project would include 123 acres for the levee alignment and 802 acres eventually consumed by induced commercial and industrial development.

b. Environmental Impacts. Construction of a levee in this area would have little impact on the natural environment. The project area lies within the urbanized part of metropolitan Kansas City, and the development of industry and transportation networks has eroded the quantity and quality of the natural environment.

The bald eagle was identified as a possible migrant in the project area, and the endangered pallid sturgeon may also be found in the project area. No impact to either species is anticipated from project activities.

One archaeological site, the Renner site which is on the National Register of Historic Places, was identified as being within the study area. The site can easily be avoided, so it would not be affected by the project.

Construction of the recommended plan would affect 16 acres of relatively low value wetlands. The affected wetlands are low in functional value because of their small acreage along with the fact that they are surrounded by intensive urban and agricultural development. Lost wetland values would be compensated by permanent easements to be obtained on riverside borrow area.

No critical, rare, or unique habitat is located in the project area.

Woodland resources are primarily limited to narrow riparian borders totaling 320 acres along the Missouri River. All timbered riparian areas would be protected during project construction.

The only public land in the study area is a locally owned softball field that would not be affected by the project.

c. Reduction of Risk. No critical facilities with harmful discharges have been identified in the project area. The Riverside Post Office incurred substantial damage in the 1993 flood and would be protected by the proposed levee.

The levee would protect the majority of flood vulnerable area of the city of Riverside and town of Northmoor. Many more people work in Riverside than live there, and most people who do live there are not in a floodplain. The main risk reduction impact on people would affect business owners and workers. About 10 residential structures and 25 residents affected by the flood of 1993 would be protected from the 500-year flood. Floods exceeding the 500-year event would still leave residences vulnerable and subject to harm.

(St. Paul District Discussion "500-Year Protection for Urban Areas")

The 1993 flood on the 25-mile reach of the Minnesota River being used as an impact study reach in the St. Paul District was approximately a 50-year event. The existing urban levees along this designated impact reach of the Minnesota River at the communities of Mankato and Henderson provided an adequate level of flood protection in 1993 and thus would have had no measurable beneficial impact relative to the 1993 event because of the lack of damages experienced at these locations. The added protection at this location would have had no systemic impact on the hydraulics of the river with respect to the 1993 event. Only the city of Henderson would require a higher level of flood protection in this river reach since it now has a 170-year degree of protection. The implementation cost of providing this higher protection is roughly estimated to be $2,770,000. The City of Mankato, the only other urban area subject to flooding in this 25-mile reach, is considered to have a 500-year level of protection.

Increasing urban levee heights at Henderson would result in a slight encroachment into the floodplain and result in the loss of a small acreage of floodplain forest. These losses would not be significant on a systemic basis. Construction activities could result in bcalized short-term minor effects on air quality, noise and water quality.

(Rock Island District Discussion "500-Year Protection for Urban Areas")

Raccoon River-Valley Drive. The Corps of Engineers 1988 feasibility study for the Raccoon River-Valley Drive levee included an analysis of 500-year protection. A levee at the 500-year level was found to have economic justification. The selected levee plan which maximized net benefits was for a 100-year level of protection as shown in Table 9-7.

Raccoon River and Walnut Creek. A Standard Project Flood levee plan was justified for the Raccoon River and Walnut Creek project by the Corps of Engineers in the June 1975 *Feasibility Study for Flood Damage Reduction and Related Purposes, Des Moines River Basin, Iowa and Minnesota.* The Standard Project Flood levee was recommended for implementation, even though the greatest net benefits were derived for the 200-year level of protection project as shown in Table 9-8.

In 1989, a General Reevaluation Report was completed by the Corps of Engineers due to changed conditions since the 1975 study. The 500-year levee was shown to be economically justified. Although the plan was demonstrated to be economically justified from the 50-year to the SPF level of protection, it was determined that a 100-year levee maximized net benefits as shown in Table 9-9. The 100-year project is currently under construction.

Table 9-7
Floodplain Management Assessment
1988 Economics, Raccoon River-Valley Drive Levee
Vicinity of Des Moines, Iowa

Category	50-Yr Levee	100-Yr Levee	200-Yr Levee	500-Yr Levee	SPF-Level Levee
Annual Benefits ($000)	177.0	246.7	283.9	317.4	332.9
Annual Costs ($000)	150.0	174.1	224.1	265.2	386.6
Net Benefits ($000)	27.0	72.6	59.8	52.2	-53.7
Benefit-to-Cost Ratio	1.2	1.4	1.3	1.2	0.9

Source: *Definite Project Report, Section 205 Flood Control Project, Raccoon River, Des Moines, Iowa, with Environmental Assessment*, U.S. Army Corps of Engineers, Rock Island District, May 1988, Page 11, Table 3.

Notes:
(1) November 1987 prices, 50-year analysis period, 8-5/8 percent discount rate.
(2) SPF = Standard Project Flood.

Table 9-8
Floodplain Management Assessment
1975 Economics, Raccoon River and Walnut Creek Levee
Vicinity of West Des Moines, Iowa

Level	Annual Cost ($)	Annual Benefits ($)	B/C	Excess Benefits ($)
50-Year	332,300	542,700	1.63	207,700
100-Year	357,800	647,400	1.81	289,600
200-Year	385,000	717,100	1.86	332,100
SPF	476,200	779,600	1.64	303,400

Source: *Feasibility Study for Flood Damage Reduction and Related Purposes, Des Moines River Basin, Iowa and Minnesota,* U.S. Army Engineer District, Rock Island, June 1975, Page F-32, Table F-16.

Notes:
(1) B/C = Benefit-to-Cost Ratio.
(2) SPF = Standard Project Flood.

Table 9-9
Floodplain Management Assessment
1989 Economics, Raccoon River and Walnut Creek Levee
Vicinity of West Des Moines, Iowa
($000)

Category	50-Yr Levee	100-Yr Levee	200-Yr Levee	500-Yr Levee	SPF Levee
Total Project Costs	6,560	17,757	18,933	20,147	25,339
Annual Charges	1,694	1,815	1,936	2,063	2,587
Annual Benefits	2,999	3,253	3,360	3,463	3,520
BCR	1.8	1.8	1.7	1.7	1.4
Net Benefits	1,306	1,438	1,424	1,400	933

Source: *General Reevaluation Report for Flood Control Project, Raccoon River and Walnut Creek, West Des Moines-Des Moines, Iowa, with Final Supplement No. 1 to the Final Environmental Impact Statement*, U.S. Army Corps of Engineers, Rock Island District, July 1989, page 23, table 4.

Notes:
(1) SPF = Standard Project Flood.
(2) BCR = Benefit-to-Cost Ratio.

Cultural Resources. Reduced flood damages would have a very positive effect on historic structures in the floodplain. Increases in residential and commercial development would negatively affect historic structures. Overall, the effect of this alternative on structures is judged to be quite positive ($^{-5}.....^{0}..._{+4}.^{+5}$).

Overall, impacts to archaeological sites from this alternative are judged to be quite negative ($^{-5}.._{4}...^{0}.....^{+5}$).

(St. Louis District Discussion - "500-Year Protection for Urban Areas")

Background. Five urban Federal levee projects are located in the St. Louis District. Only one, Cape Girardeau, Missouri, is not to the 500-year level of protection. The structural implementation cost shown in the matrix table reflects the cost of increasing the Cape Girardeau flood protection from 200-year to 500-year. There would be a slight increase in damages to unprotected areas and no change in the agricultural damages. Since no urban levees were overtopped in 1993, there is no change from the base condition.

Following are two separate special impact reach studies prepared by the St. Louis District. They are intended as general information that would be useful for similar urban areas elsewhere in the Midwest subject to major rivers flooding.

Impact Study Reach - Chesterfield Monarch Protected Urban Area

This impact study reach has been selected for analysis because it suffered significant 1993 flood damages even though it had 100-year flood protection. Data and analysis developed for the Chesterfield-Monarch area may be generally applicable for similar areas elsewhere in the

Midwest.

Background. The Chesterfield-Monarch earthen levee extends for 11.5 miles along the right bank of the Missouri River about 40 river miles upstream of its confluence with the Mississippi River. This privately financed levee protects 4,240 acres of floodplain, one-third of which is currently commercially developed. The levee also protects about 3 miles of a major transportation artery, Interstate 64.

The Chesterfield-Monarch area is an example of the extensive damages that can result when intensive urban development takes place in an area thought to be adequately protected by a levee. In this case, an existing agricultural levee was upgraded in the 1980's to provide protection up to the 100-year flood, thus meeting the minimum standards of the National Flood Insurance Program. Subsequently, industrial development took place within the protected area with the understanding that NFIP minimum standards had been met. When this private levee broke in 1993, total flood damages of about $520 million were incurred by some 250 commercial enterprises and related transportation facilities, $200 million of which was directly linked to structures and contents.

The St. Louis District, Corps of Engineers, is currently conducting a reconnaissance study of the Chesterfield-Monarch area. This analysis will consider economic (National Economic Development), social well-being, safety and environmental consequences (including residual risks) in examining the feasibility of flood damage reduction measures that may be recommended for Federal participation. The reconnaissance study is currently scheduled for completion in December 1995.

Problems identified with the Chesterfield-Monarch levee include the lack of such refinements as underseepage relief wells, interior drainage systems, lack of pumping capacity, and need for an extensive maintenance program (Shepard, 1994[1]). When the Chesterfield-Monarch levee broke, approximately 4,240 acres flooded. The area contains approximately 3.1 million square feet of commercial space, all of which was adversely affected. There are approximately 250 businesses in the Chesterfield Valley area with 4,400 employees. After the levee broke, about 8 feet of water stood in the valley, submerging almost all of the enterprises. The Spirit of St. Louis Airport (the second busiest in the State) was able to remove almost all planes before the levee broke, but three planes were damaged and several of the runways experienced damages as well. The water flowed over Interstate 64 and closed the interstate for 3 to 4 weeks.

Economic and Social Impacts. Total losses were estimated at $520 million. This figure includes lost wages, damage to contents, floodfighting efforts, moving expenses, lease value differentials, and businesses deciding to move elsewhere. Approximately $200 million of the losses were directly linked to damages to structures and contents[2].

Of considerable local interest in the Chesterfield-Monarch area is the fact that nearby Federal urban design flood protection projects did not fail. In 1993, the four Federal urban flood protection projects located within the metropolitan St. Louis area, Missouri and Illinois, prevented flood damages estimated at $2.9 billion. The occupants in the area of the Chesterfield-Monarch 100-year flood protection levee sought Congressional action for higher levels of protection resulting in this area's inclusion in the Corps reconnaissance study.

The Chesterfield-Monarch area is now in the process of restoring its levee to bring it back up to Federal Emergency Management Agency (FEMA) minimum standards for a 1 percent chance (100-year) levee recertification. Because this area is developing so rapidly (and for the reasons summarized in the previous paragraph), the Chesterfield-Monarch area has obtained Congressional authorization and funding, directing the Corps of Engineers to determine the feasibility of increasing its level of flood protection. At meetings with the Corps, the Chesterfield-Monarch area representatives have emphasized their desire to obtain protection to a 0.2 percent chance (500-year) flood elevation equal to that of the metropolitan area's other Federal urban flood protection projects.

About 2,790 acres of land within the Chesterfield-Monarch levee is available for new development. If fully developed, this area could generate almost $2,000,000 annually for the City of Chesterfield through utilities gross receipts revenues[3]. It has been estimated that full development may result in 14 to 15 million additional square feet of commercial floor space. The economic pressures to restore the 100-year existing Chesterfield-Monarch levee, and raise it to 500-year protection, are significant.

Change in Stages. The UNET hydraulic model, described elsewhere in this floodplain management assessment, has been used to simulate and analyze the urban design 500-year flood protection for the Chesterfield-Monarch area. Had this higher level of flood protection been in place and properly maintained in 1993, essentially all of the $520 million 1993 flood damages would have been prevented. This does not mean that an increase in flood protection is necessarily justified economically since an annualized benefit-cost analysis has not been accomplished. This higher flood protection would have increased the 1993 flood damages of unprotected areas immediately across the Missouri River and those upstream for a relatively short distance, by a maximum of 0.8 foot elevation. The economic and environmental impacts of a maximum 0.8 foot increase in the 1993 flood elevation have not been determined. As mentioned previously, the Corps will complete a reconnaissance study in December 1995 that will examine the feasibility of Federal participation in flood prevention measures for the Chesterfield-Monarch area.

Summary. While there is general concurrence in the desirability of reducing the vulnerability of highly developed areas from severe flooding events, arbitrarily high levels of protection could lead to inefficient use of scarce resources. The Corps reconnaissance study will identify the economic, social well-being, safety and environmental costs and benefits (including residual risks), consistent with Executive Order 12893, Principles for Federal Infrastructure Investment[4], in determining if flood damage reduction measures are recommended for Federal participation.

The $520 million 1993 flood damages that occurred within the Chesterfield-Monarch locally financed 100-year levee would have been virtually eliminated if properly designed and maintained urban design 500-year flood protection had been in place similar to the Federal urban design flood protection which exists elsewhere within the metropolitan St. Louis area.

REFERENCES:

[1] Shepard, R.C., "Floodplain Development: Lessons Learned from the Great Flood of 1993," Urban Land, Vol. 53, No. 3, March 1994, Urban Land Institute, Washington, D.C.

[2] U.S. Army Corps of Engineers, The Great Flood of 1993 Post Flood Report, Main Report and Appendices A-E, September 1994.

[3] Chesterfield Valley Development Plan, Project No. 91-PW-18, Phase 1 - Feasibility Study, August 1992, prepared by Black & Veatch in association with Development Strategies, Incorporated.

[4] Executive Order 12893 of January 26, 1994, Principles for Federal Infrastructure Investments.

Impact Study Reach - River Des Peres Unprotected Urban Area - City of St. Louis and St. Louis County, Missouri

Background. The lowermost 2.8 miles

of the unprotected River Des Peres area has been selected as an impact study reach because it suffered unprecedented 1993 flood damages and because useful basic data are readily available. River Des Peres is a heavily urbanized Mississippi River tributary with the city of St. Louis on its north bank and, with a few exceptions, St. Louis County on its south.

The St. Louis District, Corps of Engineers, is currently conducting a reconnaissance study of that portion of the River Des Peres area subject to Mississippi River backwater flooding. This analysis will consider economic (National Economic Development), social well-being, safety and environmental consequences (including residual risks) in examining the feasibility of alternative structural and nonstructural flood damage reduction measures that may be recommended for Federal participation. The reconnaissance study is currently scheduled for completion in December 1995.

Several previous flood damage abatement studies have focused on Mississippi River backwater flooding along River Des Peres. These studies addressed the feasibility of both nonstructural and structural flood protection to prevent Mississippi River flooding along River Des Peres. These studies are referenced at the end of this discussion. It was determined that the cost for a major riverfront levee was economically justified if there was no requirement to pump interior storm water accumulating during Mississippi River floods[1]. Nonstructural flood protection measures, including the possibility of buyouts, have consistently been found to be economically infeasible.

Four Federal urban design flood control projects exist in the St. Louis metropolitan area, Missouri and Illinois, near the unprotected River Des Peres area. Those existing Federal projects withstood the 1993 flood event and prevented $2.9 billion in urban flood damages. Meetings with River Des Peres floodplain occupants have revealed the strong local desire to obtain flood protection equivalent to the four adjacent Federal urban flood control projects that have successfully survived several flood events, including 1993. Data about the four existing Federal urban flood protection projects are shown in Table 9-10.

1993 Flood. The frequency of the 1993 flood event for the River Des Peres impact study reach is estimated to be between 150 and 200 years recurrence interval. In 1993, the Mississippi River inundated 691 homes and 200 businesses (891 structures) in the lowermost 2.8 miles of River Des Peres. Flood damages were more complex and more expensive to resolve than the flooding experienced in semi-urban, rural or agricultural areas because of extensive infrastructure. In 1993, the area's storm water, sanitary, and combined sewers backed up foul floodwaters into the basements of homes and businesses at considerable distances away from the overland flooded areas. Introduction of commercial, industrial, and human wastewaters into the basements of homes and businesses caused unique flood damages with associated health and sanitation problems.

During the 1993 flood, sandbags were placed on top of an emergency levee installed during and after the previous 1973 flood of record. Heroic local floodfighting efforts saved some areas, while efforts for other areas failed. Based on public meetings, local interviews and newspaper articles, the local citizens living in and near the River Des Peres floodplain appear to be of the opinion that the 1993 flood catastrophe is the worst flood event that could occur. Partially based on this misconception, local rebuilding efforts are focused on achieving levels of protection (or elevation) that match or slightly exceed the 1993 flood level.

Table 9-10
EXISTING FEDERAL URBAN FLOOD PROTECTION
METROPOLITAN ST. LOUIS AREA, MISSOURI AND ILLINOIS

NAME OF PROTECTION	AREA (ACRES)	COST[A] OF CONSTRUCTION	FLOOD DAMAGES[B] PREVENTED 1993 EVENT	ALL PREVIOUS EVENTS
ILLINOIS				
Wood River	13,700	$ 17,083,700	$ 1,245,000,000	$ 3,147,000,000
East St. Louis	61,645	69,845,100	972,000,000	2,404,000,000
Prairie Du Pont	9,560	5,995,400	3,000,000	80,000,000
subtotal Illinois	84,905	92,924,200	$ 2,220,000,000	$ 5,631,000,000
MISSOURI				
City of St. Louis	3,160	$ 79,505,200	$ 680,000,000	$ 1,589,000,000
TOTAL ILL & MO	108,053	$172,429,400	$ 2,900,000,000	$ 7,220,000,000

[A] Costs at various times of construction.
[B] Damages at October 1993 price level.

(Source: U.S. Army Engineer District, St. Louis, 30 Sep 91 project maps book and CELMS-PD-E annual report data through fiscal year 1993)

Future Larger Flood Events. Because property owners incorrectly believe that protection to the 1993 flood elevations will save them from all future flood events, the Corps and FEMA have at every possible opportunity attempted to correct that false impression. Corps analysis has recently verified estimates that indicate that the urban design 500-year flood elevation in the River Des Peres area is about 2 to 2.5 feet higher than the 1993 flood disaster. The existing metropolitan St. Louis area Federal urban flood protection projects have a top elevation another 2 feet higher, which is 54 feet on the Market Street gage. To assist property owners in assessing their future flood damage exposure, 54 feet on the Market Street gage has been plotted on maps and discussed at public meetings. Furthermore, those River Des Peres occupants who may be eligible for future buyouts on the basis that a flood reaching 54 feet on the Market Street gage will damage their structures 50 percent or more have been identified. The purpose of these efforts is to caution local property owners that preparations need to be made now to protect against future floods larger than the 1993 flood event. Table 9-11 indicates the magnitude of the local impacts of the 1993 flood event versus 54 feet on the Market Street gage. It should be noted that sewer overflow flooding caused by Mississippi River floods affects a significant number of **additional** structures.

Residential and commercial areas along the lowermost 2.8 miles of River Des Peres are continuing to suffer an economic decline intensified by the 1993 flood event. Homes and businesses are aging, and the impact of flooding further reduces property values. FEMA is relocating some structures that suffered 50 percent or more flood damage in 1993, but remaining residents are concerned that the resulting open space leaves undesirable gaps in the neighborhood, destroying community integrity. The flood insurance program does not prevent flood damages, but rather indemnifies losses after they occur.

Table 9-11
Floodplain Management Assessment
River Des Peres Impact Study Reach
Lowermost 2.8 Miles
1993 Flood Compared to 54 Feet Market Street Gage

	NUMBER OF STRUCTURES FLOODED			
	OVERLAND FLOODING		SEWER OVERFLOW FLOODING	
STRUCTURE TYPE	1993	54 FEET	1993	54 FEET FLOOD
Residences	691	3,014	NA	NA
Commercial/industrial	200	497	NA	NA
TOTAL	891	3,511	2,069	4,000+

NA = Data specific to residences versus commercial/industrial structures not readily available at this time (total estimates are being developed for reconnaissance study under preparation).

In truth, the flood insurance program may encourage some people to stay in the floodplain because some of their flood damages are then covered by insurance, in some cases, at federally subsidized rates. One apartment owner and his low income tenants have indicated they were financially ahead after suffering the previous record 1973 flood event[2].

The potential impact of larger floods on the River Des Peres impact study reach is apparent when the number of existing structures and their values are considered for a flood reaching 54 feet on the Market Street gage as shown in Table 9-12. Time and funds to conduct an exhaustive analysis of the River Des Peres flooding problems were not available during this assessment. However, the likelihood of economically justified flood control improvements does not look good based on previous Corps study results. Thus, FEMA may provide the only opportunity for Federal assistance (other than Department of Housing and Urban Development (HUD) community block grant monies) for relocation after larger magnitude floods occur in the future. Less costly alternatives such as floodproofing structures may be possible but were not developed for this assessment.

Preliminary Analysis: Buyouts and Floodwalls. A simple and incomplete analysis of the first costs of buyouts versus the first costs of a floodwall has been prepared, but these data must be evaluated with caution because they are very preliminary and do not reflect the economic worth of vacated flood- prone properties. The basic reason for identification of these values is to specifically recognize that there are no inexpensive ways to deal with urban floodplain development. The data in Table 9-13 is based on addressing the structures affected by a flood reaching 54 feet on the Market Street gage.

While there is general concurrence in the desirability of reducing the vulnerability of highly developed areas from severe flooding events, arbitrarily high levels of protection could lead to inefficient use of scarce resources. The Corps reconnaissance study will identify the economic, social well-being, safety and environmental costs and benefits (including residual risks), consistent with Executive Order 12893, Principles for Federal Infrastructure Investment[17], in determining if flood damage reduction measures are recommended for Federal participation.

Table 9-12
Floodplain Management Assessment
Existing River Des Peres Development
54 Feet Market Street Gage (1989 Price Level)

LOCATION	RESIDENTIAL COUNT	RESIDENTIAL VALUE	COMMERCIAL COUNT	COMMERCIAL VALUE	TOTAL COUNT	TOTAL VALUE
CITY OF ST. LOUIS***						
mile 0.00 - 0.85	194	$ 2,197,419	244	$29,390,381	438	$31,587,800
0.85 - 1.60	1,275	18,578,042	153	16,443,971	1,428	35,022,013
1.60 - 2.80	608	17,941,235	6	5,285,900	614	23,227,135
***subtotal	2,077	$38,716,696	403	$51,120,252	2,480	$89,836,948
ST. LOUIS COUNTY***						
mile 0.00 - 1.63	549	$ 8,318,905	94	$26,914,598	643	$35,233,503
1.63 - 2.48	331	10,332,150	0	0	331	10,332,150
2.48 - 2.80	57	2,046,060	0	0	57	2,046,060
***subtotal	937	$20,697,115	94	$26,914,598	1,031	$47,611,713
RIVER DES PERES****						
*****TOTAL******	3,014	$59,413,811	497	$78,034,850	3,511	$137,448,661

(Note: values not adjusted for 1993 buyouts, relocations, or abandonments)

Table 9-13
Existing River Des Peres Urban Development
Impact Study Reach
Approximation of Buyout Versus Floodwall Costs
54 Feet Market Street Gage

LOCATION	RESIDENTIAL AND COMMERCIAL STRUCTURES COUNT	BUYOUT COSTS	FLOODWALL	LEAST COST
CITY OF ST. LOUIS***				
mile 0.00 - 0.85	438	$ 76,700,800	NA	$ 76,700,000
0.85 - 1.60	1,428	199,000,000	$29,350,000	29,350,000
1.60 - 2.80	614	76,000,000	NA	76,000,000
***subtotal	2,480	$351,170,000	NA	$182,050,000
ST. LOUIS COUNTY***				
mile 0.00 - 1.63	643	$ 84,000,000	NA	$ 84,000,000
1.63 - 2.48	331	37,150,000	$21,150,000	21,150,000
2.48 - 2.80	57	6,040,000	NA	6,040,000
***subtotal	1,031	$127,190,000	NA	$111,190,000
RIVER DES PERES****				
*****TOTAL********	3,511	$478,890,000	NA	$293,240,000

NA = Site inspection indicated that these stream reaches would require inordinately long levees or floodwalls to protect relatively few structures, and thus, a structural solution was considered to be not applicable at this time.

(Note: values not adjusted for 1993 buyouts, relocations, or abandonments)

Potential Additional Federal Cooperation. FEMA and the Corps could further explore the possibility of additional collaborative planning focused on the social well-being of less affluent floodplain occupants. This effort could be designed to provide a more humane and fiscally responsible approach to minimizing flood damages, with an increased emphasis on nonstructural options that better address the needs of less affluent areas. For example, this collaborative planning could meld the success of FEMA's after-flood response with the Corps success in providing pre-flood urban design protection that proved to be effective elsewhere in 1993. Further, the two agencies could pursue a greater emphasis on permanent nonstructural solutions, such as buyouts, with structural alternatives pursued only if significantly less costly and if coupled with mandatory flood insurance to handle the flood events that would exceed the structural design flood.

Summary. The River Des Peres impact study reach analysis of flooding problems for a heavily urbanized unprotected urban area leads to the following observations that may be useful for similar areas in the Midwest:

1. Flood damages in urban unprotected areas are made more complex and expensive by existing infrastructure such as storm, sanitary and/or combined sewer systems.

2. Flood protection for River Des Peres at the minimum FEMA flood insurance 100-year elevation requirement would not have been effective for the 1993 flood event.

3. Flood protection for River Des Peres at the urban height 500-year elevation would have prevented most 1993 flood damages.

4. Nonstructural flood protection (buyouts) can essentially eliminate all future significant flood damages, but may be quite expensive and more disruptive to neighborhood cohesion.

5. Structural flood protection (levee/floodwall) may be less expensive than nonstructural flood protection (buyouts) for densely urbanized areas.

6. Improved collaboration between FEMA and the Corps could achieve an increased emphasis on nonstructural alternatives focused on the least costly solution for existing flood damages, to include the needs of less affluent areas.

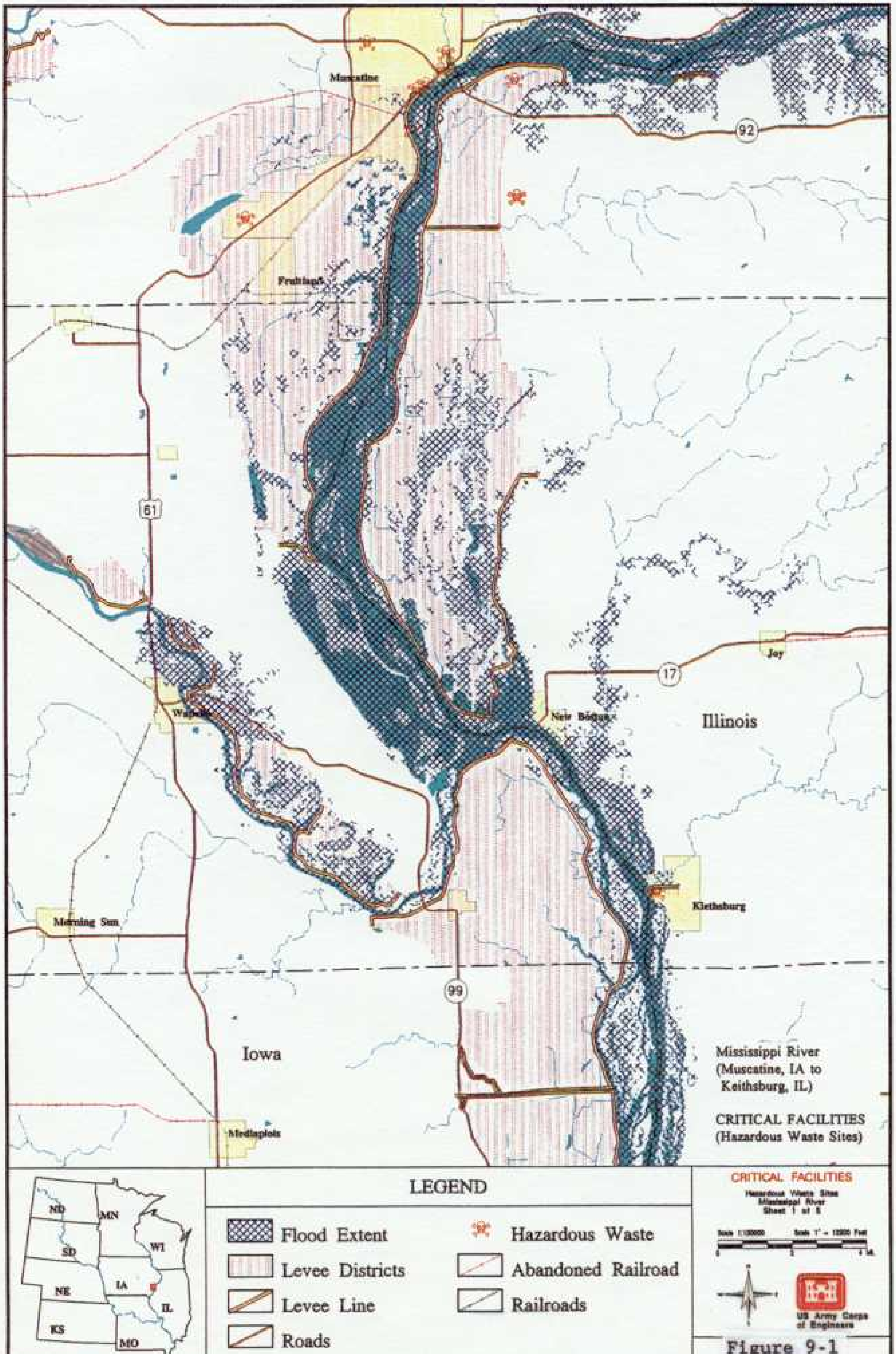
PROTECT CRITICAL FACILITY SITES TO 500-YEAR LEVEL

A discussion of the alternative of protecting critical facilities to 500-year levels of protection is provided by the Rock Island District. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Columns Q and R of the matrix tables at the end of this chapter. Figures 9-1, 9-2, and 9-3 are representative of mapping available for critical facilities. A list of critical facilities affected by the 1993 flood is provided in Attachment 4 at the end of the main report.

(Rock Island District Discussion - "Protect Priority Critical Facility Sites to 500-year Level")

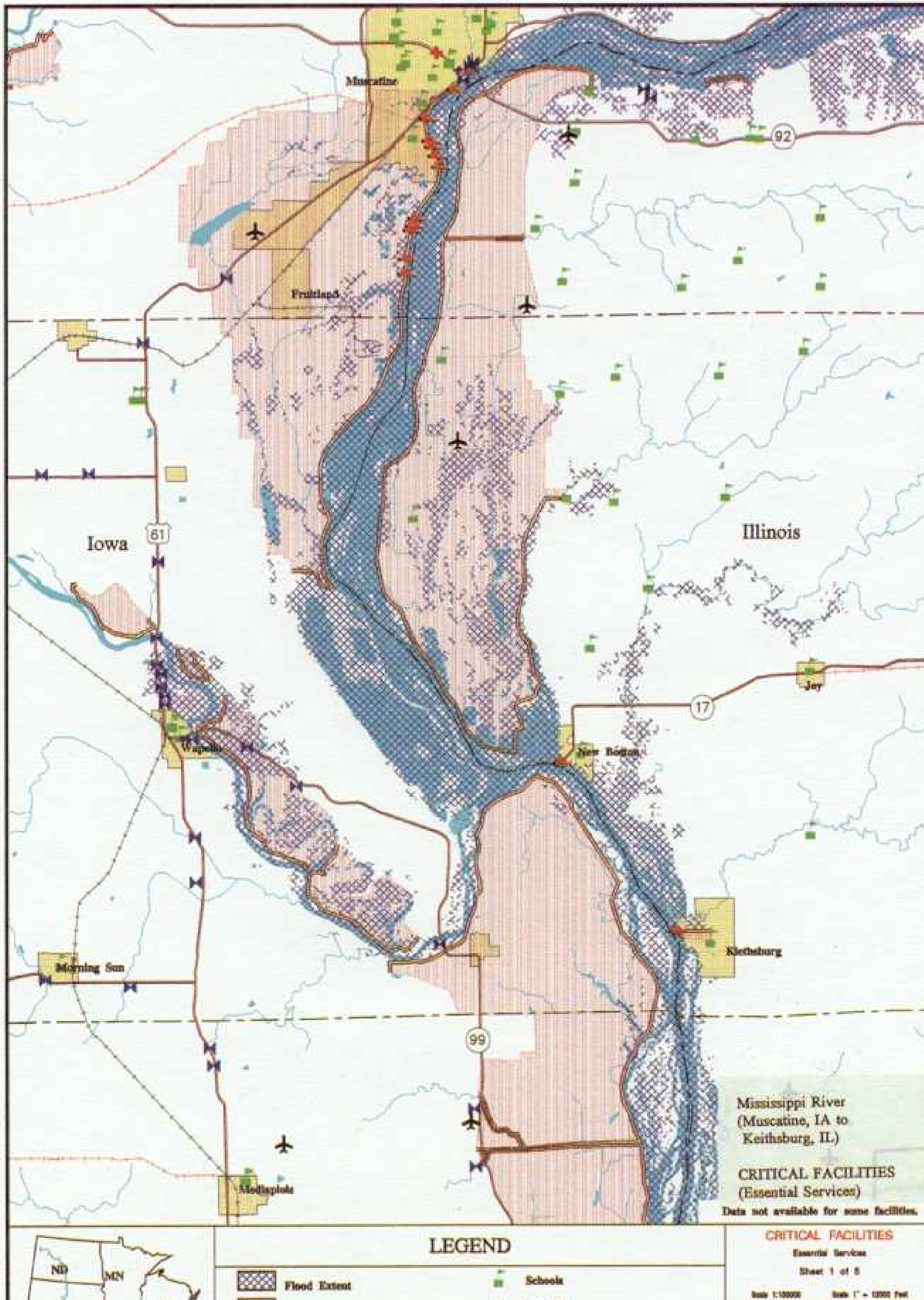
The city of Des Moines, Iowa, was used as a test case to study protecting critical facility priority sites. The level of protection would be for the 500-year flood. Only one critical facility needing additional protection was identified in the study area. The Des Moines Waterworks on the Raccoon River was overtopped by the flood of 1993. The levee protecting the waterworks was raised after the flood in 1993.

Cultural Resources. Cultural resource impacts for providing priority sites with 500-year level protection would generally have little effect on historic structures listed on or eligible for listing on the National Register of Historic Places. However, in cases where the facilities are eligible for the National Register, the effect could

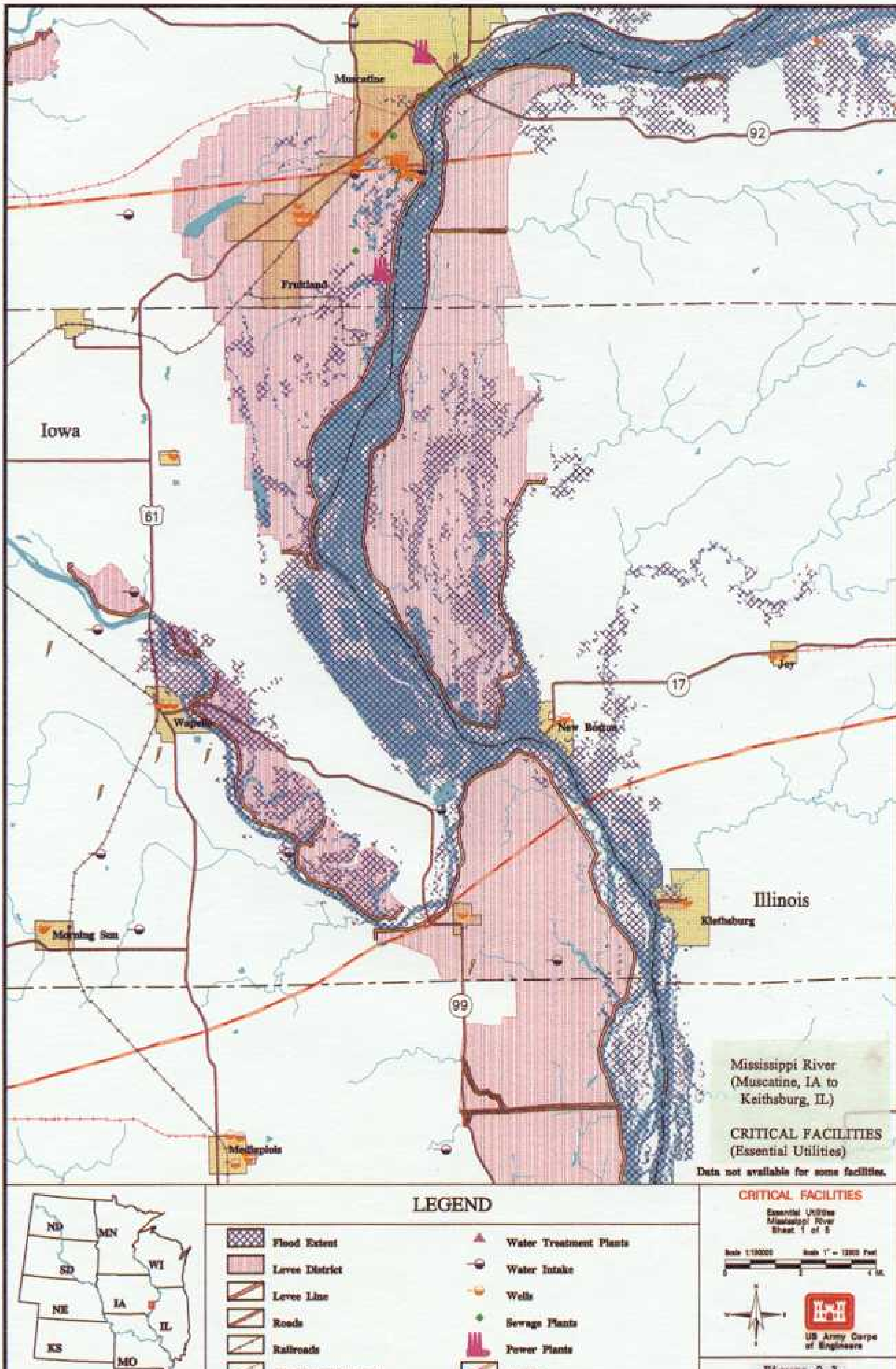


Muscatine
Fruitland
92
61
Joy
17
New Boston
Illinois
Wapello
Keithsburg
Morning Sun
99
Iowa
Mississippi River
(Muscatine, IA to
Keithsburg, IL)
CRITICAL FACILITIES
(Hazardous Waste Sites)
Mediapolis
ND
MN
SD
WI
NE
IA
IL
KS
MO
LEGEND
Flood Extent
Hazardous Waste
Levee Districts
Abandoned Railroad
Levee Line
Railroads
Roads
CRITICAL FACILITIES
US Army Corps of Engineers

Figure 9-1



Muscatine
92
Fruitland
Iowa
61
Illinois
Joy
17
New Boston
Wapello
Keithsburg
Morning Sun
99
Mediapolis
Mississippi River
(Muscatine, IA to
Keithsburg, IL)
CRITICAL FACILITIES
(Essential Services)
Data not available for some facilities.
ND
MN
SD
WI
NE
IA
IL
KS
MO
LEGEND
Flood Extent
Levee District
Levee Line
Roads
Railroads
Abandoned Railroads
Schools
Hospitals
Airports
Bridges
Prisons
Barge Facilities
CRITICAL FACILITIES
Essential Services
Sheet 1 of 5
US Army Corps of Engineers
Figure 9-2


Muscatine
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Iowa
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Wapello
Morning Sun
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Joy
New Boston
Illinois
Keithsburg
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Mediapolis
Mississippi River
(Muscatine, IA to
Keithsburg, IL)
CRITICAL FACILITIES
(Essential Utilities)
Data not available for some facilities.
ND
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IL
KS
MO
LEGEND
Flood Extent
Levee District
Levee Line
Roads
Railroads
Abandoned Railroads
Water Treatment Plants
Water Intake
Wells
Sewage Plants
Power Plants
Pipeline
CRITICAL FACILITIES
US Army Corps
of Engineers
Figure 9-3

be positive.

The primary impacts to archaeological sites would be from the acquisition of borrow. Construction access, staging, and other associated impacts also would negatively affect sites. Few, if any, benefits to archaeological sites can be predicted for this alternative.

Overall, the effect of this alternative on structures is judged to be neutral $(^{-5}\ldots\ldots{}_{0}\ldots\ldots{}^{+5})$ while the effect on archaeological sites is judged to be solidly negative $(^{-5}{}_{-4}\ldots{}^{0}\ldots\ldots{}^{+5})$.

(Rock Island District Discussion - "Protect Critical Facility Sites to 500-year Level")

The Mississippi River - Muscatine, Iowa, to Hannibal, Missouri - was used as a test case to study protecting critical facilities. Six major highway bridges over the Mississippi River were adversely affected during the flood of 1993. An inventory of critical facilities affected by the 1993 flood for the Floodplain Management Assessment impact reach study areas is found in Attachment 4 of this report. Figures 9-1, 9-2, and 9-3 are examples of the kinds of maps that can be developed to show critical facilities.

Bridge access was lost due to flooding of approach roads. Approach roads would be raised to 2 feet above the 500-year flood elevation. A standard design was used for each road consisting of two 12-foot concrete travel lanes, two 12-foot concrete shoulders, and two 6-foot gravel shoulder extensions. The embankment would be constructed of compacted fill with the side slopes protected by riprap. Affected approach roads would be raised between 7 and 17 feet, on average.

Cultural Resources. Cultural resource impacts for providing all sites with 500-year level protection would generally have some positive effects, assuming historic structures listed on or eligible for listing on the National Register of Historic Places were among the facilities in this category. For example, some historic bridges would benefit from this protection.

The primary impacts to archaeological sites would be from the acquisition of borrow. Construction access, staging, and other associated impacts also would negatively affect sites. Few, if any, benefits to archaeological sites can be predicted for this alternative.

Overall, the effect of this alternative on structures is judged to be mildly positive $(^{-5}\ldots\ldots{}^{0}{}_{+1}\ldots\ldots{}^{+5})$ while the effect on archaeological sites is judged to be solidly negative $(^{-5}{}_{-4}\ldots{}^{0}\ldots\ldots{}^{+5})$.

REMOVING EXISTING RESERVOIRS

The alternative of removing existing reservoirs was evaluated through systemic hydraulic modeling on the upper Mississippi and lower Missouri River main stems. All five Districts provide a discussion of the impacts of this alternative. The estimated changes in impacts from those actually experienced at the time of the 1993 flood are noted in Column S of the matrix tables at the end of this chapter.

(Omaha District Discussion "Removing Reservoirs")

Introduction. The six main stem reservoirs had a significant impact on reducing the peak stage experienced along the Missouri River downstream from Gavins Point Dam. It is estimated that the total main stem storage increased by more than 9 million acre-feet (maf) from June through August 1993. When combined with the 61 tributary reservoirs located within the Missouri River Division, it is estimated that a total of more than 16 maf of water was stored by the first of August. Modeling the removal of the main stem reservoirs was useful in bracketing the extreme in terms of discharge.

Change in Stages. The 1993 peak flood stage without the main stem reservoirs would have been about 9 feet higher at Sioux City, 6 feet higher at Omaha and 3 feet higher at Nebraska City. Also, the duration above flood stage would have increased from 0 to 60 days at Sioux City, from 1 to 67 days at Omaha, and from 25 to 80 days at Nebraska City. Because of the influence of the dams, the return period varied widely from a 2- to 5-year event at Omaha, Nebraska, to a 50- to 100-year event at Rulo, Nebraska.

Change in Flood Damages. Omaha District's analysis showed a saving of over $980 million in damages prevented in Omaha District alone by the system of main stem dams. Of course, the previous caveats on using these numbers in an absolute sense still apply, but the large number puts in perspective the role the reservoirs played in preventing damage and saving lives.

Change in Government Expenditures. Government expenditures for emergency response, disaster assistance, and FCIC and NFIP indemnities were estimated to increase by over $474 million. A portion of the indemnities would be prepaid by participants.

Change in Value of Floodplain Resources. Real estate value could be significantly decreased because of lower expected capacity to produce income in the future. The effect would be extremely large and very burdensome to affected landowners, communities, businesses, local taxing authorities and others. The decreases in value and any costs of dislocation, relocation, and mitigation would show up partly as financial costs and partly in decreased economic activity in the area. To estimate the total change in value of floodplain resources is beyond the scope of this assessment and requires an analysis of annualized costs and benefits. This is discussed in the section on sensitivity of results at the end of this chapter.

Change in Risk. Several cities, railroads, highways (including I-29), and critical facilities would be more vulnerable to flooding as would a very large number of acres of extremely good cropland. Also, there would now be substantial flooding in the reach between Gavins Point Dam and Omaha, Nebraska, which experienced very little flooding from the Missouri River in 1993.

Change in Environmental and Cultural Resources. In the Gavins Point Dam to Rulo, Nebraska, study area, removal of the main stem reservoirs would result in massive ecosystem reversals. There would be an immense change in land use from agricultural to natural and perhaps even from urban to natural in the floodplain. Wetland acres would increase substantially. Threatened and endangered species such as the pallid sturgeon, piping plover, and interior least tern would benefit as well as other native fish and wildlife species in the Missouri River floodplain from removal of the dams.

Cultural resources in the study area may be threatened by increased flooding.

Implementation Costs. The no-reservoir analysis was done to determine the benefit of existing reservoir retention and no implementation costs were considered. Costs of environmental and cultural mitigation, relocation of residents or businesses, and effects on local schools, communities, and relevant taxing authorities also were not quantified for project costs.

Summary. Increasing the inflow to the study reach greatly increased computed stages, discharges, damage, and risk. The increase varied throughout the reach depending on many factors, most notably distance from the main stem dams, the effects of levee failures, and inflow hydrographs. The analysis underscores the tremendous flood control benefit provided by the present system of reservoirs.

(Kansas City Discussion - "Removing Existing Reservoirs")

Change in Stages. This alternative would increase 1993 flood stages in all reaches by 0.4 foot to 5.1 feet. The St. Joseph reach would experience less than a one-half foot increase, while the Kansas City and Hermann reaches would have significant stage increases of 5.1 feet and 3.6 feet, respectively. The Waverly and Boonville reaches would have stage increases of 1 to 1.5 feet.

Change in Flood Damages. Without existing reservoirs, Residential flood damages would increase an estimated 7 percent due to increased flood stages. Other Urban flood damages would increase by more than 500 percent, mainly because the increased flood stages would cause six urban levees in the Kansas City metropolitan area to be overtopped. These levees held during the 1993 flood event.

Agricultural and Other Rural damages are estimated to have only slight increases. Less than 2,000 additional crop acres are flooded with this alternative.

Change in Government Expenditures. Emergency response costs are expected to increase with this alternative because of increased stages and increased flood fight costs, particularly in the Kansas City metropolitan area. An insignificant increase would be expected in agricultural disaster relief costs based on the slight increase in crop damages with this alternative. Disaster relief costs related to human resources could be expected to experience a significant increase based on the high increase in Other Urban damages and the increased Residential damages. NFIP payments would increase. This assumes more people would buy flood insurance with no upstream reservoirs in place, and assumes increases in payouts due to increased stages and damages with this alternative. Crop damages are slightly increased with this alternative, and more agricultural producers may purchase crop insurance in the absence of upstream reservoirs. Therefore, a low increase in FCIC payments could be expected with this altemative.

Change in Value of Floodplain Resources. In the absence of upstream reservoirs, protected crop acres (about 700,000) would have lower levels of protection and thus lower land values due to the increased stages in all the reaches. An estimated 10 percent decrease overall in the Net Agricultural Production category could be expected for the affected acres.

Without existing reservoirs, levees protecting urban (non-crop) acres would also provide lower levels of protection because of the increased flood stages in all the reaches. Six urban levees protecting more than 10,000 urban acres would overtop in the Kansas City area. The estimated decrease in the Net Urban Real Estate Value category could be about 30 percent overall for the affected areas.

Change in Risk. The number of critical facilities in both categories would be expected to increase with this alternative due to higher stages and the overtopping of the urban levees in Kansas City. The number of people vulnerable could increase significantly and the number of communities and residential structures vulnerable might also be expected to increase with the increased flood stages under this alternative.

Other Implementation Costs. Implementation costs to raise urban levees overtopped with this alternative could be high.

Summary of Alternative Without Federal Reservoirs. If the Federal reservoirs had not been in place prior to the 1993 flood, the urban damages would have increased in the range of 500 percent, because urban levees in the Kansas City area would have overtopped. It must be understood that under this alternative existing levels of flood protection would be reduced due to greater in-stream flows. Since the majority of farmland in the floodplain was inundated, the change to both the agricultural areas and wetlands without reservoirs would have been insignificant. Without reservoirs, the government recovery expenses and the number of critical facilities at risk would have been substantially increased. The market value of floodplain real estate affected would have been reduced 10 to 30 percent.

(St. Paul District Discussion - "Removing Existing Reservoirs")

Examining the 1993 flood if no reservoirs had been in place affects the St. Paul District in relatively limited ways. Because of the limited storage capacity of the reservoirs upstream on the Minnesota River, releases equaled inflows for most of the period of extensive rainfall, meaning that the downstream stages were not significantly reduced. The 1993 flood was approximately a 50-year event on the portion of the Minnesota River being evaluated. Removing reservoirs on the Minnesota River would have had insignificant effects on Mississippi River stages in the St. Paul District during the 1993 flood event.

The environmental work group assumed that this alternative would not affect land use in the downstream floodplain in spite of increased frequency of flooding (assuming existing farm program incentives). There would be no construction impacts associated with this alternative within the floodplain. Because changes in stage would be slight, changes in impact categories for the 1993 event would be negligible. For smaller events, there would be some negative impact, especially in upstream areas along the Minnesota River, if the Big Stone Lake and Lac qui Parle reservoirs were not in place.

Without the Lac qui Parle reservoir, Fort Renville and archaeological sites around the reservoir would not have suffered the adverse effects of the pool being so high for so long. In the study reach between Mankato and Henderson, the reduction in the flood height would have been negligible, and therefore the effect of the flood on archaeological and historic sites would not have changed.

In the long term, the "no reservoir" alternative would likely result in changes in land use in the floodplain of the Minnesota River because of increased frequency of flooding. In annually flooded zones, this would likely cause agricultural land to revert to a natural condition. Farming would continue in other areas depending on various Department of Agriculture incentive/price support/disaster payment programs. Lac qui Parle and Marsh Lakes are significant waterfowl staging areas during the fall migration. Lac qui Parle Lake is also an important regional fishery and recreation area. Removal of the dams would significantly alter the current nature and use of those areas.

(Rock Island District Discussion - "Removing Existing Reservoirs")

Three major flood control reservoirs located on the Iowa and Des Moines Rivers are operated by the Rock Island District. Coralville Reservoir, located on the Iowa River about 5 miles above Iowa City, Iowa, provides flood protection to Iowa City as well as other downstream communities and agricultural lands. At full flood control, its storage capacity is 435,000 acre-feet or 2.62 inches of runoff over the 3,115-square-mile drainage area above the dam. Saylorville Reservoir, located 9 miles above Des Moines, Iowa, on the Des Moines River, provides 586,000 acre-feet of flood control storage or 1.89 inches of runoff over the 5,823-square-mile drainage area above the dam. It provides flood protection to the city of Des Moines, along with the Des Moines Local Flood Protection Levee project.

Red Rock Reservoir, operated in tandem with Saylorville Reservoir, also located on the Des Moines River, provides 1,484,900 acre-feet of flood control storage which translates to 2.26 inches of runoff over the 12,323-square-mile drainage area above the dam. It is located approximately 30 miles southeast of Des Moines and provides flood protection on the Des Moines River to the communities of Tracy, Ottumwa, Eddyville and Keosauqua, Iowa, as well as to agricultural lands. Flood control benefits are also achieved along the Mississippi River. In order to determine the impact that reservoirs had on the

1993 flood, hydraulic routings were performed using reconstituted hydrographs of the 1993 flood without reservoir holdouts from Coralville, Saylorville, and Red Rock.

In general, stage reductions provided by the reservoirs along the tributaries were of vital importance in protecting property and lives in communities downstream. Without the reservoirs, levees protecting urban areas and critical facilities would have been in jeopardy. However, on the main stem of the Mississippi River, the stage reductions were minor due to the massive volume of runoff entering the system between the reservoirs and the Mississippi River.

Cultural Resources. Cultural resource impacts without reservoirs, assuming existing reservoirs reduced downstream levee failures to some extent, are judged to be slightly negative for both historic properties (additional flood damage) and for archaeological sites (additional flood damage and additional damage from repair activities).

Overall, the effect of this alternative on structures and archaeological sites is judged to be slightly negative ($^{-5}$....$_{-1}$^{0}.....$^{+5}$).

(St. Louis District Discussion - "Removing Existing Reservoirs")

Background. This alternative assumes no existing reservoir flood control storage. Not only would 25 agricultural levees overtop, but the 5 urban design levees would have overtopped. This action would cause an increase of $7 billion in economic damages from the base condition. The virtual crippling of the St. Louis metropolitan area would have devastating secondary impacts on the regional economy and nationwide transportation system.

Change in stages. Simulation of this alternative was performed to assess the effect of Federal reservoirs. Discharges were recomputed downstream of all Federal reservoirs assuming that the reservoirs were removed. Within the St. Louis District, the Federal reservoirs that affected the 1993 flood consisted of Mark Twain Lake (RM 63.0) on the Salt River and Lake Shelbyville (RM 221.8) and Carlyle Lake (RM 106.6) on the Kaskaskia River. The without reservoir discharges were computed at the New London, Missouri, gage (RM 35.3) on the Salt River and Venedy Station (RM 57.2) on the Kaskaskia River. The systemic results of removing Federal reservoirs are displayed in tables in the Hydraulics appendix (Appendix A). The peak stage increase varies from 0.3 foot at Lock and Dam 22 to 4.1 feet at Lock and Dam 26. From the St. Louis, Missouri, gage to the Cape Girardeau, Missouri, gage, the average increase is 4.0 feet on the Mississippi River. The average increase in stage on the Illinois River is 2.9 feet and on the Missouri River is 3.9 feet. The change in the hydrographs because of this alternative is shown on plates in the Hydraulics appendix. The levee performance of the Mississippi River, Illinois River and Missouri River are displayed in tables in the Hydraulics appendix. The St. Louis, East St. Louis and Prairie du Pont urban levees are overtopped in this alternative, as shown in a table in the Hydraulics appendix.

Change in damages. All St. Louis District levees including the urban protection levees and floodwalls would have been overtopped without reservoir storage. All cell entries reflect the estimated impacts.

ADDED RESERVOIRS

The alternative of providing additional reservoirs was not evaluated on a systemic basis. The Rock Island District provides a discussion of changes that may have resulted in the 1993 flood if reservoirs that at one time were proposed on the Raccoon and Skunk River basins had been in place. The St. Louis District provides a discussion of five reservoirs that were proposed in the Meramec River basin. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Column T of the matrix tables at the end of this chapter.

(Rock Island District Discussion - "Added Reservoirs")

Comparison of runoff versus storage set aside for flood control at proposed reservoirs in the Raccoon and Skunk River Basins was evaluated to determine if construction of those reservoirs would have had any significant impact on the 1993 flood.

Raccoon River Jefferson Reservoir. In 1966, an economically justified plan was formulated by the Corps of Engineers to construct the Jefferson Reservoir. The plan is described in the report *Des Moines River, Interim Review of Reports for Flood Control and Other Purposes, Jefferson Reservoir*, U.S. Army Engineer District, Rock Island, 28 January 1966.

The dam site was located in Greene County about 10 miles upstream from Jefferson, Iowa, on the North Raccoon River. The drainage area above the dam site is 1,552 square miles. The reservoir would be 24 miles in length, covering portions of Greene, Carroll, and Calhoun Counties. The narrow valley floodplain has a maximum width of one-half mile. At elevation 1090, the area that would be covered is approximately 10,700 acres. Total reservoir capacity would be 312,000 acre-feet, which includes storage allocated for sediment, water quality, and flood control. Of this, 130,700 acre-feet, which is equivalent to 1.6 inches of runoff over the basin, would be allocated for flood control storage. The reservoir would require a total of 15,200 acres of land for the project.

The cost of the project in 1966 was estimated at $17,625,000. Of that amount, $695,000 was assessed to local interests for recreational facilities. The annual charges were calculated at $738,640 and annual benefits were estimated at $1,090,931. The benefit-to-cost ratio was 1.48.

Hydrology and Hydraulics. Routing the 1993 flood through the reservoir, along with volumetric comparisons of runoff versus flood control storage, indicates that Jefferson Reservoir would have provided little benefit in reducing stages downstream in West Des Moines and Des Moines during the 1993 flood. Limited storage capacity allocated for flood control, along with the fact that the majority of runoff was contributed by the Middle and South Raccoon Rivers, presented little opportunity for flow reduction on the main stem of the Raccoon River. Table 9-14 shows monthly runoff volume in terms of multiples of allocated flood control storage capacity.

Since levee projects along the Raccoon River in West Des Moines and Des Moines have been modified to contain the 1993 flood, construction of the Jefferson Reservoir is probably no longer economically justified.

Ames Reservoir. Congress authorized the Ames Reservoir in the Skunk River basin in 1965. In October 1973, the State of Iowa withdrew support for the project. In 1984, the project was reactivated and studied in a *General Reevaluation Report, Upper Skunk River Basin, Iowa (Ames Lake)*, U.S. Army Corps of Engineers, Rock Island District, July 1987.

The General Reevaluation Report examined a variety of reservoir options. Reservoir benefits and costs are shown in Table 9-16 and are described as follows:

Table 9-14
Floodplain Management Assessment
Monthly Runoff vs. Multiples of Allocated Flood Control Storage Capacity
Jefferson Reservoir, Raccoon River

Month	Monthly Runoff in Inches Above Jefferson Reservoir	Multiples of Flood Control Capacity
March	1.86	1.2
April	3.62	2.3
May	2.52	1.6
June	2.40	1.5
July	5.40	3.4
August	2.14	1.3
September	1.12	0.7
Total	**19.06**	**12.0**

Table 9-15 shows peak discharges on the North, Middle, South, and main stem Raccoon Rivers.

Table 9-15
Floodplain Management Assessment
1993 Peak Discharges
at Gaging Stations in the Raccoon River Basin

Location	Peak Discharge in cfs
North Raccoon River near Jefferson, IA	16,900
Middle Raccoon River near Panora, IA	22,400 *
South Raccoon River at Redfield, IA	44,000 *
Raccoon River at Van Meter	70,100 *

* Denotes Record Discharge

Squaw Creek Reservoir. The Squaw Creek site is about 8.6 miles upstream from the confluence with the Skunk River. The site is 2 miles upstream from the previously studied Gilbert Dam site. Area development necessitated moving the study site upstream from the old Gilbert site. The Gilbert site was economically justified in 1970 as a single-purpose flood control project with a benefit-to-cost ratio of 1.6. The Squaw Creek site was studied as a single-purpose flood control detention dam with a dry reservoir. A multi-purpose facility including flood control was not possible because of limited storage capacity. The site has a drainage area of 160 square miles. The proposed reservoir would have a length of 4.75 miles and a capacity of 20,500 acre-feet at the spillway crest.

1968 Ames Lake (5.2-inch project). The project site is located on the Skunk River just north of Ames. The authorized project provided storage for 5.2 inches of basin runoff with a full flood pool elevation of 976 feet National Geodetic Vertical Datum (NGVD). The maximum pool would cover 7,500 acres. Flood control storage would be 89,500 acre-feet. The Ames Lake project was economically justified in 1968 with a benefit-to-cost ratio of 1.5 and a cost of $17.5 million. Due to changed conditions by 1986, the project was no longer economically justified at a cost of $88 million.

1986 Ames Lake (5.2-inch project). The 1968 plan was reformulated to update the project to present-day conditions. The reservoir size remained the same at 5.2 inches. The project was not economically justified in 1986 at a cost of $72 million.

1986 Ames Lake (3.6-inch project). A downsized reservoir was formulated to reduce adverse impacts. The project would be sized for 3.6 inches of basin runoff. The project was economically justified in 1986 at a cost of $49 million.

1986 Ames Lake (3.0-inch project). The project would be sized for 3.0 inches of basin runoff. The full flood pool was reduced to elevation 965 feet NGVD. Flood control storage would be set at 51,000 acre-feet. The project was economically justified in 1986 at a cost of $42 million.

As in the case of Jefferson Reservoir, Ames Lake and Squaw Creek reservoirs would have had little impact on reducing 1993 flood peaks. Limited flood control storage relative to runoff produces little opportunity for reduction of peak stages downstream. Table 9-17 lists monthly runoff versus multiples of allocated flood control storage capacity for both the Ames Lake 3.0-inch project and Squaw Creek reservoir.

Table 9-16
Floodplain Management Assessment
Economics of Ames Reservoir Alternatives
Skunk River
Vicinity of Ames, Iowa

Reservoir Alternative	Annual Benefits ($000)	Annual Costs ($000)	B/C Ratio
Squaw Creek	2,005.8	2,573.9	0.78
1968 Ames Lake (5.2 in)	6,173.6	8,339.7	0.74
1986 Ames Lake (5.2 in)	5,907.7	8,339.7	0.71
1986 Ames Lake (3.6 in)	5,907.7	5,338.2	1.11
1986 Ames Lake (3.0 in)	5,773.4	4,600.6	1.25

Source: *General Reevaluation Report, Upper Skunk River Basin, Iowa (Ames Lake)*, U.S. Army Corps of Engineers, Rock Island District, July 1987.

Notes:
(1) 8-5/8 percent interest rate.
(2) 1968 Ames Lake (5.2 in) benefits and costs updated to 1986 dollars.

Table 9-17
Floodplain Management Assessment
Monthly Runoff vs. Allocated Flood Control Storage Capacity
Ames Lake and Squaw Creek

Month	Monthly Runoff in Inches Above Ames Reservoir	Multiples of Flood Control Capacity	Monthly Runoff in Inches Above Squaw Creek Reservoir	Multiples of Flood Control Capacity
March	2.94	1.0	3.10	1.3
April	2.51	0.8	2.11	0.9
May	2.24	0.7	2.55	1.1
June	4.52	1.5	4.50	1.9
July	9.62	3.2	12.03	5.0
August	6.52	2.2	6.66	2.8
September	2.01	0.7	2.11	0.9
Total	**30.36**	**10.1**	**33.06**	**13.9**

Cultural Resources. Cultural resource impacts with added reservoirs, assuming added reservoirs reduced downstream levee failures to some extent, would have both positive and negative impacts on cultural resources. Negative impacts from construction and operation of the reservoirs would outweigh the positive impacts of reduced flooding downstream. Negative impacts to structures in the reservoir area would be offset to some degree by positive impacts from reduced flooding downstream. Archaeological sites downstream could benefit from less damage from levee repair episodes, but would be more likely to suffer more intensive agricultural impacts from reduced flooding and more secure levees.

Overall, the effect of this alternative on structures is judged to be mildly negative ($^{-5}\ldots_{-1}{}^{0}\ldots{}^{+5}$) while the effect on archaeological sites is judged to be solidly negative ($^{-5}{}_{-4}\ldots{}^{0}\ldots{}^{+5}$).

(St. Louis District Discussion - "Added Reservoirs")

Background. During the 1960's, five reservoirs were proposed for the Meramec River Basin. The operation of these reservoirs, if constructed, would not have had a significant impact on the 1993 flood peak stages because damaging rainfalls generally did not hit the Meramec River Basin until well after the 1993 crest.

Analysis. Additional reservoir opportunities within the St. Louis District are rare. The greatest impact of added reservoirs in the St. Louis District would be for local flood damage reduction.

REVISED OPERATION OF RESERVOIRS

The alternative of revising the operation of reservoirs was not evaluated systemically. However, the Rock Island and St. Louis Districts provide a review of reservoir operation in their Districts during the 1993 flood. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Column U of the matrix tables at the end of this chapter.

(Rock Island District Discussion - "Revised Operation of Reservoirs")

Revised operation of existing reservoirs was another measure to consider in assessing watershed management. Increased retention or revised release schedules provide two possible opportunities to reduce flood impacts. Both are discussed below relative to the 1993 flood.

Increased Retention. All three major flood control reservoirs within the Rock Island District, Saylorville, Red Rock, and Coralville, were operated beyond full flood control capacity during the 1993 flood event. Higher authority granted deviation from approved regulation plans allowing lower than prescribed release rates in order to aid floodfighting efforts in downstream communities and to minimize impacts to affected critical facilities. As a result, Saylorville and Red Rock Reservoirs on the Des Moines River rose to 2 to 3 feet above designated full flood control pool levels. Coralville Reservoir rose to nearly 5 feet above its full flood pool level. High pool levels began to affect property and facilities upstream as well as raise concerns about dam safety. Peak pool stages at all three reservoirs were coincident with the real estate ground taking line. For these reasons, increased retention beyond the range described above would not be prudent without assessing the need to acquire additional real estate holdings and adequacy of remedial works upstream of the reservoirs.

Revised Release Schedule. Revising reservoir operations by adjusting the release schedule at each of the Rock Island District flood control reservoirs was examined as a means of reducing impacts of the 1993 flood. As mentioned in the discussion on increasing reservoir retention, operation of all three reservoirs deviated from approved regulation plans during the 1993 flood.

Based upon a limited analysis, minimal impact would have been realized from increasing releases earlier in the course of the flood to conserve storage that could have been used at a more critical time. Increasing releases when the reservoir is at lower elevations would cause more frequent downstream flooding by not optimizing available storage. It must be emphasized that optimal operation of flood control reservoirs is accomplished by providing flood damage reduction for frequent, less severe flood events, as well as rare, large magnitude events.

Therefore, any revision of release schedules must consider the entire range of flood events, which is beyond the scope of this assessment. Funding is being sought to study operational and/or structural modifications at Coralville Reservoir to address changed physical, economic, and hydrologic conditions that have occurred since the reservoir went into operation.

__(St. Louis District Discussion - "Revised Operation of Reservoirs")__

After the 1993 flood, an evaluation of the operation of the St. Louis District reservoirs was made. The District has five reservoirs, but two of them were excluded from the study for reasons discussed below. The other three were found to have been operated in a superior manner.

Lake Wappapello on the St. Francis River had no impact on the Mississippi River flooding during 1993. The St. Francis River confluence with the Mississippi River is near Memphis, Tennessee, far south of the major flooding on the Mississippi River during 1993. A detailed study of Lake Wappapello was not needed and was not conducted.

Rend Lake is on the Big Muddy River. Its confluence with the Mississippi River was within the area of major flooding in 1993. However, Rend Lake's outflow is through an uncontrolled spillway. The outflow from the lake is determined by the lake level, and no reservoir operation is performed.

The Kaskaskia River has two reservoirs that provided a great deal of flood protection during the flood of 1993. The Kaskaskia River's confluence with the Mississippi River is approximately at Chester, Illinois. This area was affected by the 1993 flood. Lake Shelbyville and Carlyle Lake operated as a system. Except for backwater from the Mississippi River, the Kaskaskia River experienced no flood damage during the 1993 flood. The discharge from these two reservoirs did **not** add to the many crests or the duration of the 1993 flood. In fact, every crest of the Mississippi River in 1993 was reduced by the operation of these two projects. The operation of these two reservoirs did not prolong the duration of the flood. The two Kaskaskia reservoirs were both success stories during the 1993 flood.

Mark Twain Lake on the Salt River was an exceptionally successful case. Extremely close coordination with the downstream landowners association (LSRBA) played a critical role. Close coordination and frequent special internal river forecasts allowed the water control manager to release water at the optimum time and provide the maximum possible flood control benefits for both the Salt River and Mississippi River Basins. The Mark Twain flood control pool was filled and emptied 3.5 times during 1993 with not a single damaging release. The regulation at Mark Twain Lake was superior.

The St. Louis District's three reservoir projects all had a positive impact on the 1993 flood. No changes are needed to the water control manuals for these projects, based on post-flood analysis.

__REDUCING UPLAND RUNOFF BY 5 or 10 PERCENT__

The alternative of reducing upland runoff was evaluated as a systemic hydraulic model, with greatest emphasis on evaluation of reductions in stage and change in impacts on the Mississippi and Missouri River main stems. The Omaha, St. Paul, Rock Island, and St. Louis Districts have provided an evaluation of the impacts of this alternative. The estimated change in impacts from those actually experienced at the time of the 1993 flood are noted in Columns V and W of the matrix tables at the end of this chapter.

(Omaha District Discussion "Reducing Upland Runoff by 5 or 10 Percent")

Introduction. Various policy and structural measures exist which may reduce runoff and lower inflow rates to the river system. Assessment of the potential effect that these alternatives may have was performed by reducing inflow hydrographs to the UNET model by 5 and then 10 percent.

Change in Stages. Peak stages were reduced by a minor amount of -0.5 to -0.7 foot at most locations for the 5 percent reduction. For the 10 percent alternative, peak stage reduction varied from -0.8 foot to -1.4 feet at most locations. Peak discharge reduction varied with an average generally equal to the original 5 or 10 percent applied to the inflow hydrographs.

Change in Flood Damages. Reduction in damages with 5 and 10 percent reductions of upland runoff amounted to $6 million and $8 million, respectively.

Change in Government Expenditures. Government expenditures for emergency response, disaster assistance, and FCIC and NFIP indemnities were estimated to decrease by over $6 million with a 5 percent reduction and over $9 million with a 10 percent runoff reduction. A portion of the indemnities would be prepaid by participants.

Change in Value of Floodplain Resources. Real estate values would be modestly increased, mostly in the very marginal areas because of lower expected recurrence of flooding. To estimate the total change in value of floodplain resources is beyond the scope of this assessment and requires an analysis of annualized costs and benefits. This is discussed in the section on sensitivity of results at the end of this chapter.

Change in Risk. Vulnerability of people, residences, communities, and critical facilities to flooding would be slightly reduced.

Change in Environmental and Cultural Resources. If the reduction in upland runoff includes the creation of wetlands, grassed or treed buffer strips, conservation lands and other similar nonstructural measures, there would be an increase in wildlife habitat and an improvement in water quality which would benefit the aquatic ecosystem. On the other hand, runoff reduction could have a negative impact on the aquatic ecosystem by reducing peak flows which trigger natural river fish spawning.

There would likely be no significant effect on cultural resources as a result of this alternative.

Implementation Costs. There are no easily attainable project costs associated with the farming practices and land conservation practices needed to attain this level of runoff reduction.

Summary. There are considerable benefits to be achieved in environmental enhancement. The cost of implementing the large-scale land management changes was beyond the scope of this assessment.

(St. Paul District Discussion - "Reducing Upland Runoff by 5 or 10 Percent")

The corresponding hydraulic model outputs for decreasing the runoff by 5 and 10 percent, respectively, in 1993 flood stages for most locations along the Minnesota River downstream of Mankato, and the Mississippi River from the Minnesota River confluence downstream, are on the order of 0.5 foot for the 5 percent reduction and 1 foot for the 10 percent reduction. Given the absence of significant flood losses in these areas during the 1993 flood, little to no benefit would be realized. However, for larger events in the St. Paul District area, these alternatives could have measurable benefits.

Also to be considered are the benefits and costs that would accompany changes in policies and programs that would be required in order to achieve the amount of runoff reductions in the upland watershed areas that were assumed by the hydraulic model runs. It is estimated that roughly 2.5 million ADDITIONAL acres would need to be converted to wetland to provide storage for excess rainfall in order to achieve a 10 percent reduction in runoff for the 1993 event in the St. Paul District alone, and that 1.25 million additional acres would be needed to achieve the 5 percent reduction in runoff. It has not been determined that the number of acres with suitable characteristics are present or available for such purposes, nor does it consider that other acreage may also have to be dedicated for buffering purposes to assure satisfactory functioning of the converted wetlands. It is these kinds of changes in the upland areas that account for the estimates of changes in impacts that are provided at a conceptual level in the matrix table.

The reduction in flood damages, as shown in the matrix table, is identified as $200 million and $400 million, respectively, for the 5 and 10 percent reductions in the St Paul District. This estimate represents the damages that would have been avoided if upland agricultural lands had been converted to wetlands and, therefore, were not subject to damages. However, the change in land use in obtaining permanent conservation easements would lead to reduced property values and decreased property tax receipts. The extent of this reduction, given the large number of acres needed for conversion to achieve this level of runoff reduction, would be significant but has not been quantified.

Watershed reduction measures would be located out of the floodplain, and would not directly affect land use within the floodplain study area. It was assumed that flood reduction effects from this alternative would not indirectly affect land use in the floodplain, although long-term reductions in flood frequency in the floodplain could make agricultural production more viable, with a resulting increase in floodplain agricultural land use.

Generally, upland retention land treatment measures such as wetland restoration would have no adverse effects on cultural resources and could benefit them by reducing farming impacts. Some activities that may require extensive grading or excavation (such as terracing or construction of small retention reservoirs) could destroy or inundate archaeological sites. Therefore, the potential effect for implementing this alternative was rated as -1 for archaeological sites.

Water quality could be significantly improved due to the decreased amount of sediment and agricultural chemicals being transported to the river. Wetland restoration and land treatment would result in a substantial increase in wildlife habitat. Waterfowl and other wetland/grassland dependent species would directly benefit from these actions. On a regional basis, restoration or improvement of these habitat types would increase habitat diversity and overall habitat quality for wildlife and would provide significant recreational benefits.

Although Upland Retention alternatives do not indicate major changes in floodplain impact categories, there are significant changes that could result throughout the watershed-floodplain-river system depending on the type of retention measures used. As discussed above, to attain a 10 percent reduction of the 1993 flood would require a rough estimate of 2.5 million acres of restored wetlands. A realistic approach to upland retention would likely consist of several programs that consider conservation practices, detention ponds, wetland
restoration, etc. to attain significant upland water

storage. The most significant impacts seen in the floodplain from such measures would likely be water quality related. A major existing land set-aside program that generates significant water quality benefits is the Conservation Reserve Program (CRP). It has been estimated that the CRP will generate up to $3.5 billion in water quality benefits alone (Ribaudo, 1989) and up to $11.2 billion in overall environmental benefits (Ribaudo, Colacicco, Langer, Piper, Schaible, 1990). CRP mainly converts highly erodible lands to grassland cover, but in combination with other programs, results in wetland restoration as well. It is likely that programs of this magnitude would be required to meet such runoff reduction targets, but when viewed in the context of the recent emphasis on ecosystem management and interagency partnerships and goal setting, benefits beyond simple flood storage could make such programs feasible. Costs would be high, but benefits would also be high.

(Rock Island District Discussion - "Reducing Upland Runoff by 5 or 10 Percent")

UNET simulations assuming runoff volume reductions of 5 and 10 percent were made to determine how Mississippi River water surface profiles of the 1993 flood would have been affected. These conditions were simulated in order to gauge the sensitivity of Mississippi River stages to runoff reductions and in no way imply that a 5 to 10 percent reduction in runoff volume is achievable. However, the Hydraulics appendix (Appendix A) discusses measures that could be taken to achieve a portion of the assumed volume reductions. Table 9-18 compares the 1993 flood stages with computed stages coincident with the assumed volume reductions.

Cultural Resources. Increased retention or revised release of water could both have negative impacts to cultural resources by increasing erosion high in the flood pools, or beyond, and by increasing bank erosion in the downstream areas.

Overall, the effect of this alternative on structures and archaeological sites is judged to be generally negative ($^{-5}\ldots_{-2}.^{0}\ldots.^{+5}$).

(St. Louis District Discussion - "Reducing Upland Runoff by 5 or 10 Percent")

Runoff Reductions. These alternatives reflect the assumption of 5 and 10 percent reductions in basin-wide runoff. The 5 percent reduction in runoff would not have prevented any of the agricultural levees from overtopping, and all reductions in economic damages accrue to the lower stages in unprotected areas. The 10 percent reduction in runoff would have prevented the overtopping of four levees with the damage reductions applying to those areas as well as to the unprotected areas.

For these alternatives, the observed runoff hydrographs from all tributaries to the Missouri and Mississippi Rivers for the 1993 flood were reduced by 5 and 10 percent. The reduction was performed on each ordinate, resulting in a total volume reduction. Large retention structures on all tributaries would be needed to result in this type of total hydrograph reduction. The systemic results for the runoff reduction of 5 and 10 percent are displayed in tables in the Hydraulics appendix. The average peak stage decrease from Lock and Dam 22 to Lock and Dam 26 is 0.5 foot and 1.6 feet, and from the St. Louis, Missouri, gage to the Cape Girardeau, Missouri, gage is 0.9 foot and 1.4 feet, respectively, on the Mississippi River. The average decrease in stage on the Illinois River is 0.4 foot and 1.9 feet, and on the Missouri River is 0.5 and 0.4 foot, respectively. The change in the storm hydrographs because of this alternative is shown on plates in the Hydraulics appendix. The levee performance of the Mississippi River, Illinois River and Missouri River are displayed in tables in the Hydraulics appendix.

Table 9-18
Floodplain Management Assessment
1993 Flood Stages with Assumed Runoff Volume Reductions
Mississippi River

Location	Computed WSEL	5% Runoff Reduction Difference in Feet	10% Runoff Reduction Difference in Feet
Muscatine, Iowa	556.0	-0.7	-1.5
Burlington, Iowa	536.4	-0.9	-1.7
Quincy, Illinois	490.0	-0.9	-1.4
Hannibal, Missouri	476.0	-1.0	-1.9

SENSITIVITY OF RESULTS

The Midwest flood of 1993 was a devastating and improbable event, which exceeded the design stage of many flood protection systems, both urban and rural. Impacts were felt by a diversity of interests, both in and outside the floodplain. Evaluation of potential changes to those impacts, based on "Action Alternatives," is a difficult and imprecise undertaking.

In attempting to assess the changes in 1993 flood impacts that might be attained through the action alternatives, hydraulic modeling and associated land use analysis provided the analytical tools. It is important to realize that, due to the huge assessment area and the lack of detailed (site specific) analysis, directional changes to flood impacts are more important than absolute quantification.

The analyses conducted for this study are assessments of what would have been different in the 1993 flood if any of the action alternatives had been in place at the time of the flood. County level 1993 flood impact data and the 1993 flood event were examined and used in the systemic analyses. Results of the analyses are sensitive to the estimates of the change in the 1993 flood damages due to changes in flood stages, and to the estimates of change in the market value of land based on differences in level of protection. Interior drainage problems were not considered in the analyses. Detailed studies, with analyses of expected annual damages and benefits considering the full array of possible flood events, and resulting impacts to other areas in the system, would be required if any of the action alternatives were to be considered for implementation.

The alternatives examined address only overbank flooding on the main stems and a few reaches of major tributaries, which represented a small, but nevertheless important, portion of total damages.

Hydrologic and Hydraulic Modeling. The sensitivity of results to hydrologic and hydraulic model inputs is discussed in Chapter 8 and in more detail in Appendix A.

Effects on Real Estate Value. The desirability of investment in any of the various engineering alternatives is very sensitive to the effect on land values associated with each alternative. Sometimes an alternative may make one location more vulnerable while adding protection to another area.

Changes may involve totals larger than either project costs or incremental changes in damage from the 1993 flood. These differences in land values represent the differences among the various alternatives in the present value of all future income production. To complicate the question, the actual change in market value reflects not the present value of future productivity but people's perception of that value. And, to further complicate the analysis, the value of this agricultural land is also affected by the various governmental programs involved in agriculture.

What is required is to employ one of two methods that were not possible to fit within this assessment. The first method would be to do a comparison of the present values of all future annualized damages. The result would give the capitalized differences in the present value of expectations of future productivity. This approach is consistent with the national economic development evaluation traditionally employed by the Corps of Engineers in project evaluation.

The second method would be to find differences in values for areas of cropland vulnerable at various frequency levels and apply those estimated differences to the total area benefited or adversely affected. The benefit is that, if accurate, the answers will reflect the actual market. The problem with this approach is that the values will be based on perceptions that may not pick up differences in productivity and, more importantly, the true change in productivity from a national economic development perspective is not discovered. Typically, the market value of flooded land tends to rebound as the memory of the flood fades. The other problem is that differences in land values attributable only to differences in levels of protection are nearly impossible to discover empirically. An analysis of estimated annual damages is clearly indicated.

A third method would include the market price of any and all land negatively affected by a proposed alternative as an added real estate cost to be included in project costs. This method assumes that any land negatively affected would need to be purchased. These costs, in many cases, may be valid financial costs for any project initiation, but they do not reflect national economic development costs. The only real loss is in future income production. Even if there were a necessity to purchase land, the land would have residual value and could be leased or sold again.

This explanation, although lengthy, is necessary for three reasons: 1.) The potential magnitude of losses or gains possible because of changes in real estate value is so large that it must be considered a primary element in any such analysis. 2.) The discussion serves as a basis for future analytical work. 3.) The methods used for estimating real estate values for this evaluation varied between Districts. It is important to note that the implementation costs, therefore, will not be directly comparable.

Economic, Land Use, and Damage Data Limitations. These involve the analysis of overbank flood effects using county data totals and incomplete databases and Geographic Information System (GIS) coverages for the economic and risk reduction impacts. These impacts are noted in the Evaluation appendix (Appendix B) discussion.

Environmental and Cultural. Environmental and cultural resource impact estimations were largely conceptual in nature.

Interior Ponding. A very important phenomenon, especially in the Omaha District, affecting alternative results involves interior ponding behind agricultural levees for the 1993 event. For the various alternatives, the altering of the stage hydrograph on the Missouri River will affect interior ponding depths and duration. Interior ponding levels are affected by factors such as rainfall, runoff from contributing drainage areas, seepage, and the peak stage, timing, and duration of Missouri River hydrographs. The simplified interior drainage study determined that the alternatives examined would not cause a significant variation in ponding levels from the base condition. A brief evaluation determined that pumping requirements to prevent all damage within the levee areas for the 1993 event are prohibitive. Detailed evaluation of changes in interior ponding depth and duration for each alternative was beyond the scope of this assessment. Whether current drainage structures and pumping capability are adequate from a national economic development perspective is a question that requires further study.

SUMMARY - OVERALL EVALUATION OF ACTION ALTERNATIVES

General Summary

Hydrologic. The analysis performed illustrates that no single alternative provides beneficial results throughout the system. Applying a single policy system-wide will cause undesirable consequences at some locations. Several of the alternatives altered hydrograph timing. A complete evaluation is required prior to implementing any alternative to investigate performance for a variety of events with different inflow characteristics. Alternatives that provide a local beneficial impact by reducing flows and stages may cause downstream consequences when the timing of levee failures and hydrograph peaks is altered. Understanding results and the effects of each alternative requires the comparison of computed peak stages, discharges, and levee cell stages at all locations. All of these variables illustrate how an alternative affects performance of the flood control system as a whole.

Results of the levee removal alternative illustrated that all model results which determine a stage and discharge reduction are extremely dependent upon assumptions regarding floodplain use and flow roughness. Results of the 25-year notch and runoff reduction alternatives illustrated that timing of levee failure combined with tributary inflows altered the time at which peak stages and discharges occurred.

Economic Lessons. For the portion of damage affected in the modeling, conclusions about the desirability of implementing any alternatives should include a study of all potential flood events that would be affected. Flood damages not affected by the alternatives modeled in this assessment will require the same type of analysis indicated by these assessment results. Determination of site specific and systemic flooding expectations over a wide range of events over time is needed for structural remedies, and improvement in policy and program measures such as those discussed in Chapter 7 is needed for nonstructural remedies.

Environmental. Natural areas do not generally benefit from manipulation such as flood control. A river ecosystem is an open, dynamic system consisting not only of the open water of the main channel, but of shallows, secondary channels, cutoffs, backwaters, wetlands, and riparian woodlands. Flood control measures, such as levees, dams, and channelization, isolate rivers from their floodplains and alter the natural flood regime allowing non-riparian invaders to become established, decreasing the organic nutrient base of rivers, decreasing habitat diversity, secluding fish from ancestral spawning and feeding areas, and disconnecting hydraulic connections between wetlands and the main channel.

Periodic flooding recharges the nutrient base of the floodplain as well. In areas where annual flooding is allowed to occur unhindered, the bottomland farm fields are rich and require little supplemental fertilizer. A problem that arises from artificial fertilization is nutrient loading, which accelerates the growth of algae which deplete the dissolved oxygen levels essential for a healthy fishery. This fact illustrates the importance of riparian wetlands as filtering systems. In conclusion, the most environmentally beneficial alternatives include those which restore the natural functions of the floodplain to its original (unaltered) state.

Cultural. In all cases, it will be necessary to conduct surveys to determine the exact (or, in this case, even approximate) impacts to significant sites. There have been very few surveys conducted along the existing levee alignments and even fewer in the floodplain. Significant sites exist in the floodplain zone (steamboat wrecks, early Euro-American settlements) and in the uplands (prehistoric villages, burial mounds, lithic quarries). Once an alternative is selected, an inventory of the sites would be conducted. Following the inventory, sites with potential significance would have to be evaluated for National Register status. Any significant site would then be considered in terms of impacts. Adverse impacts would need to be mitigated.

Omaha District Summary

Scope of Economic Impacts. It is important to point out that each alternative modeled changed impacts only at the margin from what was experienced in 1993. What was modeled in these alternatives affected only the overbank flooding from the main stem system. Included in the base conditions, and not changed by these alternatives, was damage due to interior ponding, most tributary flooding, and agricultural damage due to excess precipitation. Generally, because of the main stem dams, all agricultural damage above Omaha was caused by excess precipitation or flooding on tributaries.

Several of the alternatives would reduce the impacts of a flood similar to the 1993 event, although damages that would have been prevented in 1993 were, in each case, less than the cost of implementation for that alternative.

Pumping of all interior ponding behind the Federal levees in Omaha District would not have been feasible in 1993.

Damage that would have been prevented in 1993 in Omaha District by any of the engineering alternatives would not have been sufficient, in and of itself, to pay for that alternative based on this single event, but may have merit if examined in more detail from the perspective of average annual benefits and costs covering a range of events.

Kansas City District Summary

Summary of Removing Agricultural Levees. The change in Government expenditures and reduction of risk impact categories would have been minimal. A positive aspect of levee removal is that there could have been approximately 13,000 additional acres of established forested and non-forested wetlands within the lower 500 miles of the Missouri River floodplain. It must be understood that the trade-off for this environmental benefit would be the loss of crop production.

Summary of Levee Setback in Case Study Area. Although there is an increase in acres flooded riverward of the levee, there is a larger decrease in acres flooded landward of the setback alignment. Changes in the 1993 flood stages and other hydrologic changes are negligible with this alternative.

Summary of Uniform 25-Year Height for Agricultural Levees. The alternative of having a uniform 25-year level of protection for agricultural levees would have reduced damages approximately 20 percent in the agricultural sector, with modest reductions in urban damages.

Summary of Raising Levees to Prevent Overtopping. Raising levees and floodwalls to protect against the 1993 flood would have significantly reduced damages in both the urban and agricultural sectors and reduced the critical facilities and communities at risk. The cost of this action alternative would easily exceed $2.5 billion in the Kansas City District.

Summary of Alternative Without Federal Reservoirs. If the Federal reservoirs had not been in place prior to the 1993 flood, the urban damages would have increased in the range of 500 percent, because urban levees in the Kansas City area would have been overtopped.

St. Paul District Summary

Summary of 500-Year Protection for Urban Areas. The 1993 flood on the 25-mile reach of the Minnesota River being used as an impact study reach in the St. Paul District was approximately a 50-year event. The existing urban levees along this designated impact reach of the Minnesota River at the communities of Mankato and Henderson provided an adequate level of flood protection in 1993 and thus would have had no measurable beneficial impact relative to the 1993 event because of the lack of damages experienced at these locations. The added protection at this location would have had no systemic impact on the hydraulics of the river with respect to the 1993 event.

Summary of Removing Existing Reservoirs. Removing reservoirs on the Minnesota River would have had no effect on Mississippi River stages in the St. Paul District for the 1993 flood. In the long term, the "no reservoir" alternative would likely result in changes in land use in the Minnesota River floodplain because of increased frequency of flooding. In annually flooded zones, this would likely cause agricultural land to revert to a natural condition. Farming would continue in other areas depending on various Department of Agriculture incentive/price support/disaster payment programs.

Summary of Reducing Upland Runoff by 5 and 10 Percent. The corresponding hydraulic model outputs for decreasing the runoffs by 5 and 10 percent, respectively, in 1993 flood stages for most locations along the Minnesota River downstream of Mankato, and the Mississippi River from the Minnesota River confluence downstream, are on the order of 0.5 foot for the 5 percent reduction, and 1 foot for the 10 percent reduction. Given the absence of significant flood losses in these areas during the 1993 flood, little to no benefit would be realized. However, for larger events in the St. Paul District area, these alternatives could have measurable benefits.

Although Upland Retention alternatives do not indicate major changes in floodplain impact categories, there are significant changes that could result throughout the watershed-floodplain-river system depending on the type of retention measured used.

To attain a 10 percent reduction of the 1993 flood would require a rough estimate of 2.5 million acres of restored wetlands in the St. Paul District. A realistic approach to upland retention would likely consist of several programs that consider conservation practices, detention ponds, wetland restoration, etc. to attain significant upland water storage. It is likely that programs of this magnitude would be required to meet such runoff reduction targets, but when viewed in the context of the recent emphasis on ecosystem management and interagency partnerships and goal setting, benefits beyond simple flood storage could make such programs feasible. Costs would be high, but benefits would also be high.

Rock Island District Summary

Hydraulic/land use information identifies two action alternatives as having the most potential for reducing impacts from a flood such as the 1993 event. The alternative with the greatest (and most obvious) potential impact reduction appears to be raising existing levees to heights which would contain the 1993 flood without overtopping or failing. This alternative would drastically reduce damages of all impact categories. The second potential damage reduction alternative is the removing of agricultural levees (with its attendant purchasing of formerly protected floodplain lands and placing them in natural usage). This action would, in effect, remove damageable property (mostly crops and agricultural structures) from the areas of flood risk. Also, flood stage reductions from this alternative would decrease impacts to many non-agriculture damage categories. Implementation of either alternative is unlikely in view of the enormous costs, the Federal budget austerity that is now being projected for the future, and the significant organized opposition that would be expected.

Other Action Alternatives, such as Limiting Floodfighting, Removing Agricultural Levees (with land use remaining agricultural), and 25-year Maximum Height Levees, appear to have no net potential for reducing flood impacts. While flood stages would be somewhat reduced for these three alternatives, providing some minor reduction in non-agricultural impacts, total area flooded would increase dramatically.

Levees that held during the 1993 flood due to design height or floodfight, would be limited, removed, or degraded by these alternatives. Total damages/impacts, especially agriculture-related, would increase dramatically.

Alternatives that address removing or adding reservoirs on tributary rivers, or revising existing tributary reservoir operations, have minimal impact on the main stem Mississippi River flood stages (1993). However, removing existing tributary reservoirs would greatly increase flood impacts to urban areas on the tributaries.

Raising protection levels for urban areas and priority critical facilities would, in general, significantly reduce impacts to several non-agricultural categories.

St. Louis District Summary

The effect of several alternative agricultural levee heights and locations were analyzed employing the calibrated UNET model developed for the base condition. For each alternative, the base condition UNET model was modified to reflect geometry changes required to simulate the effect on conveyance/storage within the model. Calibration parameters determined in the base condition were not altered for any of the alternatives. In reality, the alternatives alter conveyance within a cross section by changing effective flow area, land use, sediment deposition, and other factors.

Of all the alternatives, removing all agricultural levees (Alternative L) would have the greatest impact on environmental resources. All six impact categories would be affected. Substantial increases to wetlands, forest, public lands, and percent floodplain inundated would be expected, as would positive yet unquantifiable impacts to threatened and endangered species and public recreation sites. The changes to all resource categories except percent floodplain inundated are predicated on the environmental work group's assumptions that removal of agricultural levees would lead to the conversion of 15 percent of all levee-protected agricultural lands to forested/nonforested wetlands, and that these "new" wetland areas would be acquired by the Federal Government.

For the other eight alternatives that were evaluated across all environmental impact categories, only one of the six environmental variables - percent floodplain inundated - showed a change, and this occurred for only three of these alternatives: uniform height agricultural levees (Alternative N), raise agricultural levees (Alternative O), and no upland reservoirs (Alternative S). Alternative M, raising all levees from the Missouri River to Cairo, Illinois, would also affect percent of floodplain inundated, but no other environmental variables were evaluated for this option.

REFERENCES

Ribaudo, M.O. 1989. Water Quality Benefits from the Conservation Reserve Program. U.S. Department of Agriculture, Agriculture Economic Report No. 606.

Ribaudo, M.O., D. Colacicco, L.L. Langer, S. Piper, and G.D. Schaible. 1990. Natural Resources and Users Benefit from the Conservation Reserve Program. USDA ERS Report No. 672.

FINDINGS (Chapter 9)

GENERAL

9-a) The hydraulic routings performed as part of this assessment for the alternatives of removing reservoirs and removing levees verified that existing reservoirs and levees prevented considerable damage in the 1993 flood.

9-b) Without a detailed analysis of expected costs and benefits over time, it is impossible to determine whether a particular alternative is appropriate for a particular site.

9-c) Benefits for one site are usually achieved partly by costs to another site. A system-wide analysis is necessary.

9-d) One of the biggest sensitivities of results is to loss, or gain, in value of land due to changes in levels of protection, with indications that these could be very large numbers.

9-e) This assessment was not able to address combinations of alternatives, but further analyses may be warranted for combinations such as:

- Removing or setting back agricultural levees downstream of a community as a viable option to building higher urban levees.
- Removing agricultural levees in combination with localized protection of developed areas or floodproofing within the currently leveed areas.
- Reducing upland runoff in combination with minor improvements to an existing levee to achieve a higher and safer level of flood protection.

(The project costs in the above cases would include equitable compensation to those in the formerly leveed areas who would have increased risk of flooding.)

AGRICULTURAL LEVEES

9-f) Alternatives such as Limiting Floodfighting, Removing Agricultural Levees (with land use remaining agricultural), and 25-year Maximum Height Levees, appear to have little net potential for reducing flood impacts. While flood stages would be somewhat reduced for these three alternatives, providing some minor reduction in non-agricultural impacts, total area flooded would increase dramatically.

9-g) Preparation of a fully coordinated and comprehensive plan for conducting future floodfight efforts, which includes consideration of when to cease or limit Corps floodfight assistance, would be a valuable tool for improving future flood responses.

9-h) The estimated costs are $5.6 billion for raising all agricultural levees to contain the 1993 flood in just the St. Louis District. While virtually all of the agricultural levee damage would be prevented, much of the urban flood protection would be placed at risk, and substantially more of the unprotected urban development in the city of St. Louis, St. Louis County, and St. Charles County would be more severely damaged. Approximately 60 miles of unprotected Mississippi River floodplain below St. Louis, with many rural and suburban communities, would also suffer substantially increased flood damages.

9-i) The levee setback case study illustrated that setbacks of a particular Omaha District Federal levee would have prevented overtopping of that levee during the 1993 event. However, levee setbacks were also shown to have undesirable consequences such as major losses of agricultural benefits over the life of the project. If levee setback distance is such that the levee no longer overtops, results showed that a downstream rise in flow and stage is caused at the next river constriction. It is also possible that increased vegetative growth between the levee and river would increase roughness and offset some effects of the levee setback. In addition, negative im-

pacts to interior drainage would include a longer outlet channel to discharge into the river, requiring increased maintenance due to siltation.

9-j) Adopting a standard 25-year level of protection for all agricultural levees prior to the 1993 flood event would have resulted in an average stage reduction of about 3.5 feet on the middle/upper Mississippi River and about 2 feet on the Missouri River near its mouth. This decision would require implementation funding in the billions of dollars for structural modifications and real estate interests and would have resulted in significantly increased 1993 agricultural flood damages.

9-k) Interior ponding behind levees is a considerable problem for all flood events but is of particular significance in a large flood, with heavy, prolonged regional precipitation like that experienced in 1993.

CHANNELIZATION AND URBAN LEVEES

9-l There is great potential for significant flood damage in the older established cities with extensive unprotected infrastructure investments in the floodplain and critical facilities that, if flooded, could release harmful substances into the river.

9-m) The 100-year level of protection often provides a false sense of security. The Chesterfield-Monarch area, located near St. Louis, experienced $520 million damages in 1993 despite 100-year private levee protection. Also, providing a levee with only a 100-year level of protection in an urban area allows for unrestricted development within the protected area. When the 100-year flood event is exceeded, the resulting flood damages and potential for loss of life could be catastrophic. Consideration should be given to such possible consequences of exceeding the 100-year flood.

UPLAND RETENTION/WATERSHED MEASURES

9-n) The ability of reservoirs to hold back very large volumes of runoff and thus substantially reduce downstream flooding was once again proven by the 1993 flood event.

9-o) Although upland retention alternatives do not indicate major changes in floodplain impact categories, significant changes could result throughout the watershed-floodplain-river system depending on the type of retention measures used.

9-p In some situations, reservoirs may be the most cost effective and low risk means of reducing flood stages on major rivers; however, site availability and environmental concerns generally make this option non-implementable.

(The matrix tables for evaluation of alternatives considered in this chapter are provided on the following pages. Footnotes supporting some of the cell entries are provided in Attachment 5 of the main report. Further discussion of the evaluation is provided in Appendix B.)

Table 9-19

ACTION ALTERNATIVES
Omaha District

	IMPACT CATEGORIES	A [All Disast. Counties]	B [FPMA Imp. Counties]	L Remove	M Set Back [Varied]	N [25-YR.]	O Fully Confine	Q [500-Yr.] [Priority]	R [500-Yr.] [All]	S No Reservoirs	V Runoff Red 5% [Decr. 5%]	W Runoff Red 10% [Decr. 10%]
	ECONOMIC ($'s)											
	Fld.Dam.											
1	Resid.(Urban)	65,648,752	24,017,611	6,635,000	-2,398,000	243,000	-3,750,000	0	0	75,432,000	-1,639,000	-2,706,000
2	Other (Urban)	124,621,013	62,572,037	20,078,000	-1,681,000	-220,000	-2,011,000	(-)	(-)	562,893,000	-2,040,000	-2,766,000
3	Agricultural	623,863,131	109,170,412	37,300,196	-6,869,916	17,079,351	-12,199,214	0	0	277,167,943	-1,306,596	-1,588,503
4	Other Rural	30,828,538	16,249,850	5,552,077	-1,022,577	2,542,235	-1,815,834	0	0	41,256,027	-194,485	-236,446
	Chg. in Govt.Expend.											
5	Emerg.Resp.Costs	26,162,427	8,229,102	2,273,336	-821,622	83,259	-1,284,854	(-)	(-)	25,845,103	-561,567	-927,151
6	Disast.Rel.(Agric.)	323,262,416	59,583,205	20,357,762	-3,749,474	9,321,596	-6,658,107	0	0	151,273,171	-713,116	-866,976
7	Disast.Rel. (Human R.)	256,843,175	55,244,130	15,261,501	-5,515,762	558,937	-8,625,566	(-)	(-)	173,504,985	-3,769,947	-6,224,208
8	Fld.Ins. (NFIP)	22,276,574	11,690,540	3,229,577	-1,167,223	118,280	-1,825,307	0	0	36,716,425	-797,781	-1,317,142
9	Fld.Ins. (FCIC)	179,695,218	34,313,801	11,723,978	-2,159,312	5,368,281	-3,834,385	0	0	87,117,795	-410,682	-499,289
10	Net Ag Product.	NA	0	(-)	(-)	(-)	(+)	0	0	(-)	(+)	(+)
11	Net Urban RE Values	NA	0	(-)	0	(-)	0	0	0	(-)	(+)	(+)
	ENVIRONMENTAL											
	Natur. Resour. (# acres)											
12	NonForest Wetlands	not req	10,604	265	255	0	0	0	0	0	0	0
13	Threat.&Endang. (#/Occ.)	not req	25sp, 253oc	(+)	(++)	0	0	0	0	(+)	(+)	(+)
14	Forest (acres)	not req	26,236	1,967	768	0	0	0	0	0	0	0
	Natural Fldpln Functions											
15	Fld Plain Inundated (acres)		120,276	175,280	-22,281	74,661	-54,570	0	0	50,009	-5,655	-7,183
	Cultural											
16	Impacts (-5 to +5)	-2	-1	-2	-1	-1	-1	-1	-1	-1	-1	-1
	Open Space											
17	Public Lands (acres)	not req	57,852	(+)	(+)	0	(-)	0	0	0	(+)	(+)
18	Recreation sites (#)	not req	92	(+)	(+)	0	(-)	0	0	(-)	(+)	(+)
	REDUCT.OF RISK											
	Critical Facilities											
19	# Facil. w/harmf.releas.	no info.	25	38	-3	9	-3	0	0	62	-2	-2
20	# other crit. facil.	no info.	7	12	-3	1	-7	20	0	67	0	0
	Prot./Avoid. of Harm											
21	# people vulnerable	12,598	1,647	661	-277	36	-450	0	0	2,529	-292	-292
	Social Well Being											
22	# commun.vulnerable	12	8	4	-5	4	-8	less	less	0	-2	-2
23	# resid.str.vulnerable	4,230	553	222	-93	12	-151	0	0	849	-98	-98
	IMPLEMENT. COSTS											
24	Structural Costs (Low)	0	0	8,500,000	25,800,000	32,400,000	84,600,000	10,800,000	13,800,000	NA	NA	NA
	Structural Costs (High)	0	0	92,000,000	51,800,000	32,400,000	84,600,000	10,800,000	13,800,000	NA	NA	NA
25	Other Costs	0	0	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)	(*)

(*) There are a variety of additional costs which were not quantified, variously including:

1) Possible environmental and cultural resource mitigation costs
2) Loss of tax base to the state and local governments.
3) Costs of easements or land purchases by government entities. Covered in change in land use value from an NED perspective.
4) Pumping costs.
5) Social and occupational dislocation and psychological hardship.

Table 9-20

ACTION ALTERNATIVES

KANSAS CITY DISTRICT

		A	B	L	N	O	S
				ACTION ALTERNATIVES AFFECTING HYDRAULIC CONDITIONS			
				AGRICULTURAL LEVEES			UPLAND RETENTION/ WATERSHED MEASURES
	IMPACT CATEGORIES	Base Cond. [All Disast. Counties]	Base Cond. [Floodpln. Impacts]	Remove	Uniform Ht. [25-YR.]	Raise	Without Reservoirs
	ECONOMIC (1,000 $'s)		[1]				
	Flood Damages						
1	Residential (Urban)	$102,326	$72,556	-7%	-4%	-50%	7%
2	Other (Urban)	$650,251	$541,462	-10%	-5%	-(75-90)%	500%
3	Agricultural	$1,373,434	$303,322	+(0-2)%	-20%	-80%	Insignificant
4	Other Rural	$118,447	$75,509	+(0-2)%	-20%	-80%	Insignificant
	Chg. in Govt.Expend.						
5	Emergen.Resp.Costs	$19,423	$16,332	-	-	-	+
6	Disaster Relief (Agric.)	$210,198	$64,762	NC	-low	-high	Insignificant
7	Disaster Relief (Human R.)	$285,853	$166,510	-low	-low	-high	+high
8	Flood Insurance (NFIP)	$100,779	$46,687	Insignificant	-NC to low	-	+
9	Flood Insurance (FCIC)	$185,389	$92,975	+	-NC to low	-high	+low
	Chg.Value of FP Resources						
10	Net Ag RE Values	-	-	-20%	4%	30%	-10%
11	Net Urban RE Values	-	-	-20%	Insignificant	-	-30%
	ENVIRONMENTAL						
	Natur.Resour.(# acres)						
12	Non-Forested Wetl. (acres)	-	42,700	+5,600	NC	NC	NC
13	Threat.&Endang. (# / Occ.)	-	30/80	+	-	-	NC
14	Forest (acres)	-	58,200	+7,100	NC	NC	NC
	Natural Fldpln.Functions						
15	Fldpln.inundated (acres)	-	100%	NC	NC	-90%	NC
	Cultural						
16	Archeol Impacts (-5 to +5)	-		-1 (-1)	-3 (-1)	-3 (-1)	0 (-1)
16A	Hist.Sites(-5 to +5)			-1 (-1)	-1 (-1)	-1 (-1)	0 (-1)
	Open Space						
17	Public lands (acres)	-	43,100	NC	NC	NC	NC
18	Recreation sites (#)	-	20	NC	NC	NC	NC
	REDUCT.OF RISK						
	Critical Facilities						
19	# Facil. w/harmful releases	-	27	NC	Insignificant	-NC/low	+
20	# other critical facilities	-	76	NC	Insignificant	-low/mod	+
	Prot./Avoid. of Harm						
21	# people vulnerable	28,375	21022	-low	-low	-mod/high	+mod/high
	Social Well Being						
22	# communities vulnerable	229	141	-2%	-3%	-(20-70)%	+
23	# resident.struct.vulnerable	8711	6287	-7%	-5%	-53%	+
	IMPLEMENT. COSTS						
24	Structural Costs	-	-	+$16.4 MIL +LERRD	+$340 MIL +LERRD	+$2.5 BIL +LERRD	?????
25	Other Costs	-	-	High	Low	Moderate	High

[1] Economic impacts collected only at the county level

Table 9-21

ACTION ALTERNATIVES
St. Paul District

	IMPACT CATEGORIES	A	B	B'	B"	P	S	V	W
		Base Cond. [All NCS]	Base Cond. [Floodpln-NCS]	Base Cond. Pools7-10 MS Riv.	Base Cond. MN Riv.	URBAN LEVEES [500-Yr.]	UPLAND RETENTION Without Reservoirs	Runoff Red. [Decr. 5%]	Runoff Red. [Decr. 10%]
						(1)	(2)	(3)	(3)
	ECONOMIC ($000's)								
	Fld.Dam.								
1	Residential (Urban)	$21,460	$5,428			0	0	0	0
2	Other (Urban)	$39,466	$25,918			0	0	0	0
3	Agricultural	$484,674	$95,155			0	0	-200,000	-400,000
4	Other Rural	$6,868	$2,599			0	0	-2,875	-5,750
	Chg. in Govt.Expend.								
5	Emergen.Resp.Costs	$10,226	$4,193			0	0	0	0
6	Disaster Relief (Agric.)	$283,614	$52,295			0	0	-118,750	-237,500
7	Disaster Relief (Human R.)	$254,508	$60,359			0	0	0	0
8	Flood Insurance (NFIP)	$2,237	$1,370			0	0	0	0
9	Flood Insurance (FCIC)	$215,668	$31,391			0	0	-87,500	-175,000
	Chg.Value of FP Resources								
10	Net Ag RE Values	-	-			0	0	HIGH	HIGH
11	Net Urban RE Values	-	-			+< 5%	0	0	0
	ENVIRONMENTAL								
	Natur.Resour.(# acres)								
12	Non-Forested Wetl. (acres)		74,805	21,000	2,230	-	0	0	0
13	Threat.&Endang. (# / Occ.)		75/406	54/243	6/7	-	-	+	+
14	Forest (acres)		76,095	39,000	4,530	0	0	0	0
	Natural Fldpln.Functions								
15	Fldpln.inundated (acres)					0	-	-	-
	Cultural								
16	Archeol Impacts (-5 to +5)		-1	-1	-2	-2(0)	-2(0)	-1(-1)	-1(-1)
16A	Hist.Sites(-5 to +5)		-1						
	Open Space								
17	Public lands (acres)		77,000	47,000	2,214	0	0	0	0
18	Recreation sites (#)		127	46	8	0	0	0	0
	REDUCT.OF RISK								
	Critical Facilities								
19	# Facil. w/harmful releases		3			0	0	0	0
20	# other critical facilities		13			0	0	0	0
	Prot./Avoid. of Harm								
21	# people vulnerable	11,677	5,700			0	0	0	0
	Social Well Being								
22	# communities vulnerable	64	16			0	0	0	0
23	# resident.struct.vulnerable	2,246	1,371			0	0	0	0
	IMPLEMENT. COSTS								
24	Structural Costs	-	-			+2,770	-	0	0
25	Other Costs	-	-			-	-	+1,250,000	+2,500,000

(1) Changes in impacts relative to column B"
(2) Changes in impacts relative to column B'
(3) Changes in impacts relative to column A (economics) and column B (environmental)

File:ACTNCS1

Table 9-22

ACTION ALTERNATIVES
Rock Island District

																5/9/95
	ROCK ISLAND DISTRICT			ACTION ALTERNATIVES AFFECTING HYDRAULIC CONDITIONS												
		A	B	K	L	L1	L2	M	N	O	P	Q	R	S	T	U
		BA[illegible] CONDITIONS			AGRICULTURAL LEVEES						URBAN	CRITICAL FACILITIES		UPLAND RETENTION		
	IMPACT CATEGORIES	NCR Disaster Counties	NCR FPMA Counties	Limited Flood Fighting	Remove	Remove (n=0.08)	Remove (n = 0.32)	Set Back	25-Year Maximum Height	Raise to Contain '93 Flood	500-year Urban Levees	500-Year Priority Crit. Fac.	500-Year All Critical Facilities	Without reservoirs	Added reservoirs	Revised reservoir operation
				POTENTIAL FOR REDUCING FLOOD IMPACTS (1993 EVENT)												
	ECONOMIC															
	Flood Damage							Not								
1	Residential (Urban)	$203,000,000	$129,000,000	<-5%	-5-20%			Yet	<-5%	>-90%	>-90%	None	None	*	Minimal	None
2	Other (Urban)	$350,000,000	$262,000,000	<-5%	-5-20%			Modeled	<-5%	>-90%	>-90%	Moderate	Moderate	*	Minimal	None
3	Agricultural	$1,170,000,000	$140,000,000	<-5%	-10-50%				<-5%	>-50%	None	None	None	#	Minimal	None
4	Other Rural	$20,000,000	$9,000,000	<-5%	-10-20%				<-5%	>-50%	None	None	None	#	Minimal	None
	Change in Gov't Expend.															
5	Emerg. Response Costs	$128,000,000	$97,000,000	<-5%	-50%				<-5%	>-50%	>50%	Moderate	None	*	Minimal	None
	Disaster Relief															
6	Disaster Relief (Agric.)	$307,000,000	$72,000,000	<-5%	-10-50%				<-5%	>-50%	None	None	None	#	Minimal	None
7	Disaster Relief (Human Res.)	$366,000,000	$135,000,000	<-5%	-5-20%				<-5%	>-90%	>90%	Moderate	Moderate	*	Minimal	None
	Flood Insurance Payments															
8	NFIP	$113,000,000	$83,000,000	<-5%	-5-20%				<-5%	>-90%	>90%	None	None	*	Minimal	None
9	FCIC	$12,000.00	$7,000,000	<-5%	-10-50%				<-5%	>-50%	None	None	None	#	Minimal	None
	Change in Value of Floodplain Res.															
10	Net Ag Land Values			0	-30-40%			-60-70%	-5-10%	+5-10%	None	None	None	-low	Minimal	None
11	Net Urban RE Values			<+5%	+5-25%				<+5%	25%	+low	None	None	*	Minimal	None
	ENVIRONMENTAL															
	Natural Resources															
12	Non-Forested wetland (acres)		61,000	no chng		3,900	121,000	3,900	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
13	Threatened & Endangered (#)		68	61		61	61	61	61	61	7	7	7	7	7	7
13a	Threatened & Endangered (# occur.)		250	237		237	237	237	237	237	13	13	13	13	13	13
14	Forest (acres)		138,000	no chng		no chng	252,000	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
	Natural Floodplain Functions															
15	Floodplain Inundated (acres)			416,000		491,000	497,000		494,000	159,000	no chng	no chng	no chng	unavail	unavail	unavail
	Cultural Impacts (-5 to +5)															
16a	Historic Structures		-2	+4	-5			-3	-4	+4	+4	0	+1	-1	-1	-2
16b	Archeological Sites		-2	+4	+4			-3	-1	-2	-4	-4	-4	-1	-4	-2
	Open Space															
17	Public Lands (acres)		131,000	no chng		no chng	373,000	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
18	Recreation Sites (#)		202	no chng		no chng	300	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
	REDUCTION OF RISK															
	Critical Facilities															
19	# Facilities w/harmful releases	151	134	@	@			@	@	@	@	@	@	@	@	@
20	# Other critical facilities	1,282	881	low	low-mod.				low	high	high	High	high	*	Minimal	None
	Protection/Avoidance of Harm															
21	# People vulnerable	70,000	44,000	low	low-mod.				low	high	high	None	None	*	Minimal	None
	Social Well Being															
22	# Communities vulnerable		78	low	low-mod.				low	>-90%	high	None	None	*	Minimal	None
23	*# Residential Structures vulnerable*	*18,000*	*11,000*	*low*	*low-mod.*				*low*	>-90%	*high*	None	None	*	Minimal	None
24	Implementation Costs ($000's)			5,800	829,000			248,000	3,200	290,000	25,000	Moderate	101,000		High	
	NOTES:															
	1. @ No known releases in 1993 flood.															
	2. * Potential for huge increases to urban flood damages and impacts.															
	3. # Potential for moderate increases to agricultural/rural impacts.															
	4. Agricultural levee costs do not include LERRD															
	5. *Urban levee is construction costs for West Des Moines*															

Table 9-23

ACTION ALTERNATIVES
St. Louis District

		A	B	K	L	M	N	O	P	Q	R	S	T	U	V	W
								ACTION ALTERNATIVES AFFECTING HYDRAULIC CONDITIONS								
		Base Con	Base Cond.		AGRICULTURAL LEVEES				URBAN	CRITICAL FACILITIES		UPLAND RETENTION/WATERSHED MEASURES				
	IMPACT	[All Disast	[Floodpln.	Limited	Remove	MR&T	Uniform Ht.	Raise	LEVEES	[500-Yr.]	[500-Yr.]	Without	Added	Revised	Runoff Red.	Runoff Red.
	CATEGORIES	Counties]	Impacts]	Fld.Fighting	W\Crop	MRC	[25-YR.]		[500-Yr.]	[Priority]	[All]	Reservoirs	Reservoirs	Operation	[Decr. 5%]	[Decr. 10%]
	ECONOMIC (*$000's*)		[1]													
	Fld.Dam.															
1	Resid.(Urban) (millions)	NA	431.4	NA	-60.4	NA	26.1	-43.7	14.3	NA	NA	1,860.1	NA	NA	-0.7	-18.5
2	*Other (Urban) (millions)*	NA	549.3	NA	-78.5	NA	33.0	-55.2	0.0	NA	NA	2,388.5	NA	NA	-0.3	-27.9
3	Agricultural (millions)	NA	168.6	NA	8.8	NA	72.5	-126.4	0.0	NA	NA	101.2	NA	NA	-2.9	-13.3
4	Other Rural (millions)	NA	57.2	NA	3	NA	24.6	-42.9	0.0	NA	NA	5.5	NA	NA	-1.0	-15.0
	Chg. in Govt.Expend.															
5	Emerg.Resp.Costs(millions)	NA	101.8	NA	-14.3	NA	2.5	-13.8	0.0	NA	NA	439.6	NA	NA	-0.3	-7.6
6	Disast.Rel.(Agric.) (millions)	NA	36.4	NA	1.8	NA	0.9	-27.3	0.0	NA	NA	20.3	NA	NA	-0.4	-16.0
7	Disast.Rel.(Human R.)(mill)	NA	134.3	NA	2.9	NA	2.9	-13.3	0.0	NA	NA	575.9	NA	NA	-0.3	-6.3
8	Fld.Ins. (NFIP) (millions)	NA	133.7	NA	26.7	NA	8.1	-13.7	0.0	NA	NA	68.5	NA	NA	-0.7	-6.7
9	Fld.Ins. (FCIC) (millions)	NA	44.9	NA	19.3	NA	19.3	-33.7	0.0	NA	NA	26.9	NA	NA	-0.9	-3.8
	Chg.in Value of FP Res.															
10	Net Ag Product.	NA	NA	NA	-255.5	-73	73	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	Net Urban RE Values	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	ENVIRONMENTAL															
	Natur. Resour. (# acres)															
12	Non-Forested Wetlands	NA	154,990	NA	65,750	NA	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0
13	T & E Species	NA	35/96	NA	+	NA	0/0	0/0	0/0	0/0	0/0	0/0	NA	NA	0/0	0/0
14	Forest	NA	251,110	NA	74,150	NA	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0
	Natural Fldpln.Functions															
15	*% of fldpln.inundated*	NA	80	NA	15	-25	10	-62	0	0	0	19	NA	NA	0	0
15A	Cultural Archaeological	NA	-4	-4 (0)	-5 (-3)	-1 (-2)	-4 (-1)	-1 (-2)	-4 (-1)	-4 (-1)	-4 (-2)	-5 (+2)	-3 (-5)	-4 (-4)	-4 (-4)	-3 (-5)
16	# sites impacted Historical	NA	-3	-3 (0)	-2 (-1)	0 (-1)	-3 (0)	0 (-1)	0 (-1)	-2 (-1)	-1 (-2)	-4 (+1)	-3 (-4)	-3 (-3)	-3 (-3)	-3 (-4)
17	# acres public lands	NA	96,785	NA	139,900	NA	0	0	0	0	0	0	NA	NA	0	0
18	# of recreation sites	NA	60	NA	+	NA	0	0	0	0	0	0	NA	NA	0	0
	REDUCT.OF RISK															
	Critical Facilities															
19	# Facil. w/harmf.releas.	NA	18	NA	0	NA	0	-3	0	-18	-18	24	NA	NA	0	0
20	# other crit. facil.	NA	231	NA	0	NA	0	-147	0	0	-231	249	NA	NA	0	-17
	Prot./Avoid. of Harm															
21	# people vulnerable	NA	62,180	NA	6,199	NA	6,199	-44,670	0	0	0	188,620	NA	NA	0	-2,520
	Social Well Being															
22	# commun.vulnerable	NA	50	NA	8	NA	8	-27	0	0	0	21	NA	NA	0	-4
23	# resid.str.vulnerable	NA	23,460	NA	3,000	NA	2,340	16,850	0	0	0	73,240	NA	NA	0	-950
	IMPLEMENT. COSTS															
24	Structural Costs (millions)	NA	NA	NA	44.0	5,704.0	141.0	6,071.0	51.0	85.0	1,175	NA	NA	NA	NA	NA
25	Other Costs (millions)	NA	NA	NA	1,536.0	0.0	447.0	0.0	0.0	0.0	0	NA	NA	NA	NA	NA
															File: LMSALT3.wk4	

CHAPTER 10 - OTHER SEPARATE ISSUES INVESTIGATED

General

Some of the issues raised through the originally specified objectives or comments received were not readily addressed through the evaluation framework which analyzed a wide array of alternatives. These issues have been investigated separately and are reported on in this chapter. The issues addressed here include the following:

1) Examine differences in Federal cost sharing for construction and maintenance of flood control projects on the upper and lower Mississippi River system. (page 10-2)

2) Is the responsibility for repair of flood damage to levees consistent and fair? (page 10-6)

3) How would the damages prevented due to reservoirs have been affected if wet antecedent conditions had used most of the storage on the Missouri River? (page 10-8)

4) Are bridge constrictions a significant factor affecting flood stages? (page 10-11)

5) Are there inconsistencies between States in the administration of floodplain regulations? (page 10-13)

6) Do flood control projects induce development in floodplains? Are the effects of induced development properly accounted for? (page 10-17)

7) What are some measures that could be taken to provide more sophisticated river modeling? (page 10-28)

8) Are levees considered to be part of the navigation system? (page 10-29)

9) Evaluate the impact of navigation projects on flooding, including effects of sedimentation in pools. (page 10-31)

1). Examine differences in Federal cost sharing for construction and maintenance of flood control projects on the upper and lower Mississippi River system.

BACKGROUND

The primary Federal construction agencies for water resources projects such as levees and floodwalls have traditionally been the Corps of Engineers (Corps) and the Soil Conservation Service (SCS). More recently, these Federal agencies have been joined by the Federal Emergency Management Agency (FEMA), the Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD) in the repair of non-Federal levees damaged by the 1993 flood, and in the construction of new or improved levees as a result of that flood. The analysis herein is focused primarily on the 1993 flood and the main stem of the upper and lower Mississippi River.

Some of the agencies mentioned have not used the same engineering standards or methods of economic and environmental analysis in carrying out their programs. The differences rest with the purposes of those programs and the varying nature of the levees. Most agencies are not concerned with the need for consistency between other agency programs because they only are responsible for administering programs as determined by Congress or as delegated within narrow guidelines. Nevertheless, these differences cause confusion among those dealing with the multiple programs. In addition, cost-sharing differences exist between the programs of different Federal agencies, which encourages non-Federal sponsors to shop around for the best Federal deal. Many instances exist where levee repairs by one or more Federal agencies were considered inappropriate only to be done later by another Federal agency.

The differences in Federal cost sharing for construction and maintenance of Corps flood control projects on the upper and lower Mississippi River system originate from fundamental differences in the character of the river which are reflected in the rationale for Congressional authorizations for the upper and lower river. The lower Mississippi River system is focused on a system that serves both navigation and flood control needs. On the other hand, the Congressional authorizations for the upper Mississippi River system require the Corps of Engineers to study navigation and flood control projects individually and separately and to pursue independent project(s) justification.

The drainage area of the Mississippi River at St. Louis is 697,400 square miles, 76 percent of which (529,400 square miles) is accounted for by the Missouri River and 24 percent of which (168,000 square miles) is drained by the upper Mississippi River. The geomorphology of the upper Mississippi River leads to the recognition that a middle Mississippi River reach must be differentiated from the upper Mississippi River for reasonable analysis purposes. This difference exists for several reasons, including: flooding differences due to the drainage areas of the Missouri River versus the upper Mississippi River as described previously; the upper Mississippi River upstream of St. Louis is generally confined within a more narrow bluff to bluff area; and the navigation locks, dams, and pools upstream of St. Louis on the upper Mississippi River essentially confine the river to a relatively well-defined normal channel. Consideration also needs to be given to two significant characteristics of all past major floods at St. Louis: (a) they have been produced by intense and prolonged rainfall in several States over watershed areas well upstream from St. Louis; and (b) the preponderance of the flow of the Mississippi River at St. Louis has been contributed by the Missouri River. This latter characteristic can be noted as far back as the 17th century from observations made by Marquette and Joliet during their exploratory trip down the Mississippi River in the summer of 1673, at which time the Missouri River was discharging large quantities of water into the Mississippi River.

The flood control projects on the middle Mississippi River (St. Louis to Cairo, Illinois) and a portion of the upper Mississippi River have been pursued under the auspices of the Corps Lower Mississippi Valley Division (LMVD) which is also responsible for the lower Mississippi River system. A more uniform system of agricultural and urban flood control projects exists for the middle Mississippi River than for the upper Mississippi River. For example, all of the Federal agricultural levees from Alton to Gale, Illinois, in the middle Mississippi River area have a uniform 50-year design elevation. The Federal urban projects in the St. Louis metropolitan area have a uniform 500-year design elevation. It is recognized that full consideration must be given to the economic, social well-being, safety, and environmental consequences (including residual risks) in determining the appropriate sizing of levee and floodwall projects. The various project design elevations which maximized net tangible national benefits were not recommended for the projects mentioned, in order to obtain the benefits associated with uniformity of flood fighting activities and area-wide Federal system conformity. Furthermore, the possibility of local or regional levee height competition (for example Missouri versus Illinois, or one community against another even within a common metropolitan area) was avoided by adoption of uniform agricultural and urban Federal flood control project design standards.

A summary of the differences in the Corps approach for the lower and upper Mississippi River main stem follows. The Corps approach to water resources planning for smaller tributary streams is basically the same for upper and lower Mississippi River areas.

(1). <u>Lower Mississippi River and tributaries system</u>. The lower Mississippi River and Tributaries (MR&T) flood control project was authorized in 1928. Section 2 and portions of Section 6 are reproduced as follows:

Section 2. "That it is hereby declared to be the sense of Congress that the principle of local contribution toward the cost of flood-control work, which has been incorporated in all previous national legislation on the subject, is sound, as recognizing the special interest of the local population in its own protection, and as a means of preventing inordinate requests for unjustified items of work having no material national interest. As a full compliance with this principle in view of the great expenditure estimated at approximately $292,000,000, heretofore made by the local interests in the alluvial valley of the Mississippi River for protection against the floods of that river; in view of the extent of national concern in the control of these floods in the interests of national prosperity, the flow of inter-state commerce, and the movement of the United States mails; and, in view of the gigantic scale of the project, involving flood waters of a volume and flowing from a drainage area largely outside the States most affected, and far exceeding those of any other river in the United States, no local contribution to the project herein adopted is required."

Section 6. ".... work on the *Mississippi* River between Rock Island, Illinois, and Cape Girardeau, Missouri, and on such tributaries, the States or levee districts shall provide rights of way without cost to the United States, contribute 33-1/3 per centum of the costs of the works, and maintain them after completion...." Subsequent legislation has generally established a minimum 75 percent Federal and 25 percent non-Federal cost sharing requirement for construction of Corps local protection flood control projects.

As a result of the Congressional directives, the MR&T is an integrated system that provides comprehensive flood protection to an area of over 23,000 square miles, and also inseparably provides dependable navigation on the river. The system-wide flood control approach is based on the fact that: major floodwaters affecting the area originate primarily from many States and two Canadian provinces; flooding durations resulting from such a large drainage area are measured in several months rather than days; and the lower river requires stabilization to protect the levees and maintain an adequate navigation channel. All components of the lower Mississippi River system act together to provide flood protection and navigation on the river.

(2). Middle and Upper Mississippi River. The upper Mississippi River is the area upstream of the Missouri River at St. Louis. All navigation locks and dams are located in the upper Mississippi River area, except for Lock 27 which is located about 10 miles downstream of the mouth of the Missouri River on the Chain-of-Rocks Canal. As discussed previously, the Mississippi River upstream of St. Louis is not characteristic of the river between St. Louis and Cairo, Illinois. Therefore, the following discussion focuses primarily on the middle Mississippi River because of its similarity to the lower Mississippi River and the differences from the upper Mississippi River (above St. Louis).

Currently, flood control and navigation projects on the middle (and upper) Mississippi River are justified, authorized, and constructed independently of one another. The various Congressional authorizations for the middle (and upper) Mississippi River flood control projects generally require 25 percent non-Federal cost sharing for construction, with operation and maintenance costs 100 percent non-Federal. Historically, construction and ongoing operation and maintenance costs for navigation projects were considered to be 100 percent Federal. Currently, for new general navigation projects, the costs are shared 50-50, with the non-Federal costs supplemented with contributions from the barge industry through user taxes on fuel. The cost sharing for multiple-purpose reservoir projects that include flood control and/or navigation as a project purpose follow the specific Congressional authorizing requirements, which generally follow the provisions of the 1936 Flood Control Act.

A system of urban and agricultural levees was authorized and constructed on the middle Mississippi River between St. Louis and Cairo, Illinois. The flood control design for the middle Mississippi River reach was established from hypothetical flood studies and from estimated actual events. The estimated peak discharge of the 1844 flood was used as an "urban design flood" to uniformly size the levees/floodwalls for the metropolitan St. Louis area. Recent study of the 1844 event has shown this peak discharge to be severely overestimated, with an actual estimated value of about 900,000 cubic feet per second (cfs). The 2 percent annual chance (50-year) flood was selected for uniform system design of the agricultural levees. At the time of analysis, the 1844 peak discharge (estimated as 1,300,000 cfs) was believed to be the 0.5 percent annual chance (200-year) flood event. With the addition of the many upstream Federal flood control reservoirs, primarily on the Missouri River system, the annual risk of this peak discharge is now estimated to be no more than 0.2 percent (500-year average recurrence interval).

ANALYSIS

The MR&T system, as originally conceived, extended north to Lock and Dam 16 on the Mississippi River. Funding, however, has been provided only for major improvements below Cairo.

The Congressional authorization for the lower Mississippi River required the Corps to establish a coordinated least cost (most economical) flood control/navigation system at essentially 100 percent Federal cost. One reason for the high Federal cost was that the levees existing at the time of Congressional authorization had all been constructed at 100 percent non-Federal cost (see Section 2 of the Flood Control Act of 1928 as previously quoted). The middle and upper Mississippi River flood control program was pursued at various times later. Historically, the non-Federal contribution consisted of providing the lands, easements, and rights-of-way and other requirements of the 1936 Flood Control Act. Currently, the cost sharing for new projects is based on the Congressional authorization which generally requires 25 percent non-Federal construction cost sharing and 100 percent non-Federal operation and maintenance costs. The lower Mississippi River system is authorized to exercise a greater Federal role and cost sharing for the various reasons mentioned previously.

An estimate has been prepared to approximate the construction costs of a system for the middle Mississippi River that would match the level of protection afforded by the MR&T project. If these levee raises were to occur for the middle Mississippi River, peak flows would increase flood stages up to and including the MR&T project flood level in the vicinity of Cairo, Illinois. The evaluation of these potential impacts is complex and beyond the scope of this assessment. However, any future studies that consider changes in the present middle Mississippi River levee system should include the evaluation of these downstream effects. The costs to raise all agricultural and urban levees in the middle Mississippi River are estimated to be approximately $5.7 billion. This analysis is not intended to imply that such expenditures would be economically justified. Full consideration would need to be given to all the economic, social well-being, safety, and environmental consequences (including residual risks) in determining the desirability of raising the existing middle Mississippi River levees and floodwalls. The costs for this system have not been prepared in detail and are thus only a "ballpark" estimate of the costs necessary to provide a uniform levee flood protection system equivalent to that which exists on the lower Mississippi River. If this project were constructed and properly maintained, the middle Mississippi River navigation channel alignment would be further stabilized.

From a hydraulic and geomorphologic point of view, the relative effects and interrelationships of levees and channel improvement works on Mississippi River navigation may vary in proportion above and below Cairo, but they are significant in both reaches. Areas around Ste. Genevieve, Red Rock, Miller City and Dry Bayou (all above Cairo) are dramatic examples of the Mississippi River wanting to create a new channel or occupy an old abandoned channel of geologic origin. Geomorphologic studies of the Mississippi River above Cairo and the aftermath of the 1993 flood have identified several areas with the potential for major river cutoffs and the creation of new channels. Adequate river engineering data exists to preclude using the word "stable" to describe natural conditions in the open river reach of the middle Mississippi River (Cairo to St. Louis).

FINDINGS:

10-a) The upper Mississippi River, above the Missouri River at St. Louis, exhibits characteristics considerably different from the middle and lower Mississippi River, due to a relatively narrower floodplain and to a relatively stable channel alignment that is well defined by existing navigation locks, dams and pools.

10-b) The middle Mississippi River (St. Louis to Cairo, Illinois) is subject to flood events with greater discharge than the upper Mississippi River (above St. Louis).

10-c) Extending the lower Mississippi River's system approach upstream throughout the middle Mississippi River for a dual flood control and navigation purpose is engineeringly feasible, but would require specific Congressional direction and may not be economically feasible because the estimated costs are approximately $5.7 billion.

2). Is the responsibility for repair of flood damage to levees consistent and fair?

BACKGROUND

The 1993 flood damaged about 1,600 levees, of which about 1,400 were non-Federal. Less than 500 of these levees are under the Corps emergency repair program, and of these, 229 were Federally constructed. Many of the levees that had previously been under the Corps program were not under it at the time of the 1993 flood for various reasons including: failure to operate and maintain the levee in accordance with Corps requirements; individual decisions not to participate; lack of, or the loss of, a public sponsor; or an inability to meet the required engineering criteria. In 1993, a total of 199 levees were approved for repair.

Because of the seriousness of the 1993 flood, and the fact that less than 15 percent of the non-Federal levees that were damaged qualified for repair under Public Law 84-99 Emergency Repair Program (administered by the Corps), the Administration and Congress provided supplemental funding for levee repair and relaxed the eligibility criteria. The Administration and Congress stipulated that levee districts or sponsors would have to meet the following requirements to receive funding:

(a). agree to join the Corps program; and,

(b). within 2 years, provide public sponsorship that would ensure levee maintenance and that would meet engineering, environmental, and other eligibility requirements of the Corps program.

ANALYSIS

The responsibility for levee repair is not consistent and varies considerably between Federal agencies as does the required local cost sharing. These inconsistencies exist for various reasons including congressional action and laws. Furthermore, during and after the occurrence of a major flood declared to be a national disaster, all local responsibilities can be adjusted by agency rule making or by executive order.

The differences in levee repair criteria became apparent during and after the 1993 flood as local sponsors and elected officials applied for help to various agencies and learned they could shop for the best deal. The following brief comparison of the Corps, Soil Conservation Service (SCS), and the Federal Emergency Management Agency (FEMA) requirements shows how the responsibility for levee rehabilitation varies among Federal agencies.

(1). CORPS. The Corps requires 20 percent local cost share for projects under the Corps Public Law 84-99 program, but no local cost share for federally constructed levees. Generally, the Corps uses procedures based on Principles and Guidelines (P&G established in 1983) for determining eligibility for cost sharing.

(2). SCS. SCS requires a 25 percent local cost share for like restoration work. The SCS does not use Principles and Guidelines (P&G), but evaluates whether a project has economic defensibility for determining if a project is eligible for assistance. It is important to note that neither the Corps nor the SCS is required to use P&G criteria, but each agency makes its own determination. The SCS believes that Congress determines criteria by establishing the work as emergency and the agency must only assure that what is protected has a value which exceeds the cost. The Corps has determined that the full range of P&G criteria should apply; therefore, the Corps criteria is more stringent.

(3). FEMA. When the President declares a national disaster, FEMA requires a 25 percent local cost share for restoration under the Stafford Act unless changed by the President. During the 1993 Midwest flood, the President changed the FEMA local cost share requirement to 10 percent.

FINDINGS:

10-d) The responsibility for repair of levees is not consistent between various Federal agencies.

10-e) It is the intent of the Corps of Engineers to apply its levee erosion repair policies in a consistent manner throughout the United States.

3). How would the damages prevented due to reservoirs have been affected if wet antecedent conditions had used most of the storage on the Missouri River?

Analysis was performed to assess the effect of reservoir storage on peak flow rates during the 1993 event for the base and wet antecedent conditions. Within the Omaha District, major Federal reservoirs include the six main stem dams on the Missouri River upstream of Gavins Point Dam at river mile 811.1. The Missouri River Division Reservoir Control Center (RCC) annually computes the without reservoir hydrograph at Gavins Point Dam based on routed upstream inflows. UNET modeling was performed employing the without reservoir flow hydrograph computed by RCC for inflow into the model instead of the actual 1993 reservoir releases. All other parameters were unchanged from the base condition. The without reservoir hydrograph computed by RCC at Gavins Point did not contain any large peaks flows during the 1993 event. Discharge generally varied from 60,000 to 90,000 cfs for a 3-month period. Essentially, the without reservoir hydrograph is equivalent to adding substantial base flow to the Missouri River for the 1993 event. Refer to the 1993-1994 Missouri River Main Stem Reservoir Annual Operating Plan report for details regarding system inflow, pool levels, and operation of the main stem reservoirs.

An extended drought occurred in the upper Missouri River basin from 1987 through 1992. Early in 1993, reservoir pool levels within the six main stem reservoirs were at record low levels since 1967 when all the reservoirs were first filled to their normal operating pool levels. During the 1993 flooding on the Missouri and Mississippi Rivers, the Missouri River main stem reservoir system stored a significant volume of runoff. Gavins Point Dam released minimal flows well below normal releases for the flood period in order to alleviate downstream flooding to the extent possible.

A. Revise 1993 Reservoir Releases

During the July 1993 peak flooding period, reservoir releases from Gavins Point averaged 8,000 cfs. Release volume from Gavins Point totaled 2.06 million acre-feet from June through August 1993. Reservoir release rates corresponded with minimal releases required for downstream water uses. The minimal flow released from Gavins Point Dam had no effect on downstream flood levels. Further reduction of reservoir releases during the 1993 flood event would not have been practical or beneficial.

B. Antecedent Conditions

An analysis was performed to evaluate reservoir releases of antecedent conditions in the upper Missouri River for the following conditions: 1) reservoir pools at or near normal levels at the start of the 1993 flood; and 2) if conditions had been such that the reservoir pools were at the base of exclusive flood control pool elevations.

1. Normal Conditions. Normal antecedent conditions were assumed to be represented by reservoir pool levels at an average end of month pool elevation for May instead of the lower 1993 levels which were due to drought conditions. At normal May end of month pool levels, there is approximately 14.7 million acre-feet of available storage in the six reservoirs. This would have been sufficient capacity to hold almost all of the 13.5 million acre-feet inflow into the reservoirs during the period June through August 1993. At the lowest reservoir, Gavins Point, excess inflow from the Niobrara River would have been within what was released during the 1993 operation of the reservoirs. Table 10-1 lists normal pool elevations compared to actual 1993 pool elevations for the end of May. Although operation procedures may have varied slightly, analysis determined that the excess inflow into Gavins Point would have been less than the volume released during the actual 1993 operation of the reservoirs. Therefore, additional releases in 1993 would not have been

required if initial pool levels had been at normal levels.

2. Wet Conditions. Extremely wet antecedent conditions were assumed to be represented by reservoir pool levels at the exclusive flood control pool elevation. Assuming all six reservoir levels at the exclusive flood control pool level constitutes a rare event. In the 27 years since all the reservoirs were filled to their normal operating pool, the end of month May pool elevation at every one of the six main stem reservoirs has been below the elevation of the exclusive flood control pool. If antecedent conditions had been such that only the exclusive flood control zone was available in the main stem Missouri River reservoirs, analysis determined that approximately one-third of the inflow would have been captured by the reservoirs. Following normal operation procedures, actual 1993 operation captured approximately 80 percent of the inflow. Although capacity to store near 100 percent of the inflow was available, minimal releases during the summer of 1993 were necessary for downstream water uses. The no reservoir alternative modeled with UNET assumed zero percent capture of inflow. Reservoir releases for extremely wet conditions are bracketed between computed results for the base and the no reservoirs alternative UNET models.

C. Summary

Analysis was conducted to evaluate the effect of reservoir releases for different antecedent conditions in 1993. Although operation procedures may have varied slightly, analysis determined that additional releases would not have been required if pool levels had been at normal levels. Extremely wet antecedent conditions were represented by pool levels at the exclusive flood control zone. In this case, approximately one-third of the total inflow to the reservoir system would have been stored. Downstream impacts would be bracketed between the UNET model computed results for the base condition and the no reservoirs alternative. The examination of antecedent conditions illustrates that, with the exception of extremely rare circumstances, main stem Missouri River reservoir volume would usually allow a release schedule similar to the observed (minimal) 1993 releases. Table 10-1 shows the main stem Missouri River reservoirs, the end of month pool elevation for May, the top of exclusive flood control pool elevations, and the total storage volume available.

Table 10-1 Available Storage Based on the Average End of Month Pool for May Missouri River Main Stem Reservoirs					
Main Stem Reservoir	**Average EOM Pool for May (Ft @ M.S.L.)**	**May 31 1993 Pool Elevation (Ft @ M.S.L.)**	**Exclusive Flood Control Pool Top Elev. (Ft @ M.S.L.)**	**Total Storage Volume Available* (Ac-Ft)**	**Total Inflow Volume Jun-Aug 1993 (Ac-Ft)**
Fort Peck Dam	2236.7	2213.3	2250.0	3,110,000	3,460,000
Garrison Dam	1837.9	1822.9	1854.0	5,590,000	5,920,000
Oahe Dam	1608.2	1600.2	1620.0	4,080,000	1,900,000
Big Bend Dam	1420.5	1420.9	1423.0	148,000	110,000
Fort Randall Dam	1357.4	1355.7	1375.0	1,680,000	430,000
Gavins Point Dam	1205.6	1206.1	1210.0	125,000	680,000

* Refers to the available storage volume between the May average end of month pool elevation and the top of the exclusive flood control elevation at each of the reservoirs.

<u>FINDING:</u>

10-f) On the Missouri River, additional releases would not have been required if the pool levels had been at normal levels. Therefore, there would not have been greater damages if wetter antecedent conditions had preceded the 1993 flood.

4). Are bridge constrictions a significant factor affecting flood stages?

Most bridges spanning a river in the United States are designed with an opening sufficient to pass a flood discharge of an identified magnitude. Some bridge openings were sized by empirical methods which reflect the local geographical conditions or another methodology dependent on the designer's experience. Older bridges reflect the contemporary technology as well as the economic conditions of the era. Newer bridge designs recognize Federal standards to control encroachments into a floodway. More consistent and generic criteria have been adopted which have caused an increase in the amount of bridge opening that must be provided to pass a given flood event without generating a calculated measurable adverse impact on the upstream community or surroundings.

All bridges, both railroad and highway, which presently span the Missouri River channel are theoretically sufficient to pass flood discharges equal to or greater than a 100-year flood with minor stage increases upstream. Unfortunately, this fails in practice whenever a flood event exceeds the upstream channel confinement and the flood discharges are not contained to the width of the bridge openings. That is, while a 100-year flood discharge might pass through a particular bridge opening, only part of an actual 100-year flood might pass beneath the bridge. When a portion of the flood volume goes into floodplain storage, and the roadway is on a low fill embankment, water often overflows or breaches the roadway and continues down the floodplain. If roadway fill is high, a measurable stage increase will occur at the bridge.

We can generally state that the water surface downstream of the bridge and embankment will immediately return to the stage or depth normal to natural conditions. This is true for all frequency of events that exceed flood stage.

During the 1993 flood, we observed conditions similar to those described above at the following locations:

- Prior to the breaching at the railroad crossing near Rulo, Nebraska;
- I-635 above Kansas City, Missouri;
- At the railroad crossing near Glasgow, Missouri;
- I-70 near Rocheport, Missouri; and
- Highway 63 at Jefferson City, Missouri.

Where the Federal levees near St. Joseph, Missouri, or through the metropolitan area of Kansas City, Missouri, confined the 1993 flood, we observed little to no measurable losses attributable to bridge or roadway embankments encroaching on the floodplains.

If no levees along the lower Missouri River had failed, then probably a flood between the 25- and 10-year event would pass without any attention being given to the effects of bridges and or their roadway embankments.

Among the numerous combinations of bridge openings and embankments crossing the Missouri River floodplain, each alignment is unique to the local topography and the alignment of the channel. Each configuration results in part from the economic climate at the time of construction. Because the slope of the Missouri River is fairly steep, the backwater effects from encroachment are not cumulative and dissipate very rapidly. Natural encroachments are one of the primary causes of increased flood stages and do accumulate effects upstream. However, in bridge analysis, these encroachments are considered to be a natural part of the river's environment.

Under present standards for a new bridge or embankment in the floodplain, especially within the designated floodway, each proposal is hydraulically analyzed and examined against the standards of several Federal as well as State and local agencies before it receives all the necessary permits for construction. The hydraulic examination uses the current physical conditions and assumes geotechnical aspects are not subject to failure. In contrast to these assumptions, the Missouri River's channel bed is constantly in motion and will scour during a flood to accommodate increases in stress, particularly from velocity. As the channel velocity increases, the bed will degrade to allow the channel to transport a greater portion of the discharge. Discharge measurements collected by the U.S. Geological Survey (USGS) show, prior to the private levees failing along the Missouri River, the channel capacity was accommodating some 90 to 95 percent of the total discharge at about 8.0 to 9.0 feet per second average velocity. This variable tendency of the Missouri River bed means that standard bridge analysis techniques are more conservative when applied to Missouri River bridges than to streams where the channel bed is more resistant.

Most hydraulic analyses do not examine exposed flanked conditions or changes in velocity. Federal Emergency Management Agency (FEMA) criteria do not allow for any measurable increases in water surface elevation within the designated floodway. A computed change of 0.01 foot is FEMA's guideline, which is much less that can be measured accurately in the field.

In summary, Missouri River bridges associated with high roadway embankments may have caused a backwater effect in the 1993 flood. Where they did occur, these effects were confined to a short distance immediately upstream of the bridge, were not systemic or cumulative along the river, and were generally attributable to unique local conditions. Modern methods for bridge opening design or sizing of a constriction tend to discount the potential for overbank flow losses. Consequently, whatever losses may be assumed in the design represent the worst case, and are probably less than losses that do exist and yield some additional discharge higher than the bridge opening design.

<u>FINDING:</u>

10-g) Even in an event as massive and widespread as the 1993 flood, the effects of bridges are essentially isolated and unique to each bridge and its associated floodplain. Some bridges designed to produce no increase in the 100-year flood profile did produce increased upstream stages when they could not pass the much larger 1993 flood flow, but the effect was primarily localized.

5). Are there inconsistencies between States in the administration of floodplain regulations?

INTRODUCTION

This section provides an overview of the floodplain management programs in each of the States within the Floodplain Management Assessment.

The descriptions highlight the differences between States in the administration of floodplain regulations.

All of the States in this assessment had floodplain zoning regulations in place prior to the "Flood of 93" that exceeded National Flood Insurance Program (NFIP) minimum standards, with the exception of Missouri. Model ordinances are developed by FEMA Regional Offices and by States to reflect any more restrictive State standards or unique State administrative procedures. FEMA minimum floodplain management criteria at 44 CFR 60.3(d) limit increases in flood stage when floodways are designated by communities to no more than 1 foot. Several of the States in the study area have more restrictive surcharge limitations which FEMA recognizes in its mapping. Once a floodway has been designated, obstructions in that floodway cannot cause any increase in flood stage. Buildings must be elevated or floodproofed to the 100-year or base flood elevation. The 1-foot freeboard also is a more restrictive requirement of several of the States. Ordinances do not typically address protection requirements for structures built between the 100-year and 500-year elevations.

Floodways are defined as the channel of a river and that portion of the overbank floodplain that carries most of the flood. Regulations require that the floodway be kept open so that floodwaters can proceed downstream and not be obstructed or diverted onto other properties.

FEMA also defines two occasions when work on a structure is considered a substantial improvement:

- an improvement made to a building that exceeds 50 percent of the value of the building; or

- reconstruction of a building, the value of which exceeds 50 percent of the value of the building before it was damaged.

If an addition to an existing building is a substantial improvement, then the addition must be protected from the base flood (100-year flood elevation). If a reconstruction project is a substantial improvement, then the entire building must be protected from the base flood.

COMPARISON

All of the States in this assessment currently have floodplain zoning regulations that exceed minimum NFIP standards, with the exception of Missouri. Missouri does not currently have any separate State-level legislation governing development within floodways or the 100-year floodplain.

The State of Missouri has passed statutes enabling counties, incorporated towns and cities to participate in the NFIP. Eighty-three percent of the communities in Missouri that require floodplain management programs currently have programs that meet NFIP requirements. The State has provided consistent review of ordinances, and when asked by local officials, the State reviews permits, mitigation proposals and enforcement so that Missouri communities can gain entrance or maintain eligibility for the NFIP since 1980.

The States of Wisconsin, Minnesota, Iowa, Nebraska, Illinois and Kansas have gone beyond the minimum FEMA standards and have passed their own legislation to govern development within floodways and the 100-year floodplain. Each State adheres to most, if not all, of the following basic policies:

- restrict development within floodways (do not allow obstructions);
- prohibit or discourage the development of hazardous waste facilities within floodways;
- require elevation on fill or floodproofing for structures built within the 100-year floodplain; and
- require substantially improved structures to meet zoning requirements.

The States of Illinois, Iowa, Minnesota and Wisconsin take the restrictions on development within floodways one step farther, stipulating that only open space uses (agricultural, recreational, etc.) be permitted in floodways. These States, however, have strict provisions for the construction of certain types of structures within floodways if they support an open space use and meet construction requirements.

The States of Iowa, Minnesota, Nebraska, and Wisconsin also exceed the NFIP minimum requirements for the zoning of critical facilities.

- The State of Iowa currently requires that hospitals and like institutions; buildings or building complexes containing documents, data or instruments of great public value; buildings or building complexes containing materials dangerous to the public or fuel storage facilities; power installations needed in emergencies or buildings or building complexes similar in nature to these uses be protected to the 500-year flood elevation plus 1 foot. Wastewater treatment facilities, and habitable residential buildings or industrial facilities where flooding would result in high public damages, will be protected to the 100-year flood elevation plus 1 foot.
- In Minnesota, local communities have administrative responsibilities for assuring that all public utilities and facilities such as gas, electrical, sewer and water supply systems located in the floodplain be floodproofed in accordance with the State Building Code or elevated above the Regulatory Flood Protection Elevation (RFPE). The RFPE is an elevation no lower than the 100-year flood elevation plus any increase in flood levels resulting from the designation of flood fringe areas. The Minnesota Department of Natural Resources strongly encourages all communities to also include at least 1 foot of freeboard in their local ordinance.
- The State of Wisconsin prohibits the placement of solid or hazardous waste disposal facilities in flood fringe areas (that portion of the floodplain outside of the floodway, which is covered by floodwater during a 100-year event). Public utilities, streets and bridges in the flood fringe must be adequately floodproofed.

State floodplain zoning programs compared to the NFIP are summarized in Table 10-2.

Table 10-2. State Floodplain Zoning Programs that Exceed NFIP Requirements			
States	*Floodways*	*Flood Fringe*	*Critical Facilities*
llinois			
Iowa			
Kansas			
Minnesota			
Missouri			
Nebraska			
Wisconsin			

The floodplain management handbooks published by the States of Minnesota and Illinois to assist local communities in implementing floodplain management ordinances and programs are good examples of complete, concise and easy to read products. These handbooks provide step-by-step procedures for communities to follow when establishing programs to meet NFIP requirements.

It is also important to note that State floodplain zoning regulations are written at varying levels of complexity. Some State regulations can be easily understood by laypersons, while others require a regulatory expert to provide interpretations. The floodplain zoning regulations published by the States of Minnesota and Illinois are also good examples of understandable products.

FINDINGS:

10-h) With the exception of Missouri, the States studied under this assessment have viable floodplain management programs. Their floodplain zoning regulations are consistent with those set forth in model ordinances, and in some instances are more stringent. The States of Iowa, Minnesota, Nebraska, and Wisconsin currently exceed the NFIP minimum zoning standards for floodway, 100-year flood elevation, and critical facility siting and protection.

10-i) Among the seven FPMA States, annual funding to administer floodplain management ranges from $35,000 to $1 million (1991); the average is about $400,000.

10-j) The State of Missouri has focused its efforts since the "Flood of 93" on acquiring and relocating at-risk structures in the floodplain, giving it one of the most aggressive programs reviewed. The Missouri program will acquire or relocate 4,143 structures. The State is also in the process of reviewing legislation to implement a floodplain zoning ordinance in an effort to establish a State-level program.

10-k) The States of Illinois, Iowa, Kansas, Minnesota and Wisconsin have also developed aggressive acquisition and relocation programs to reduce the level of flood damages experienced during the 1993 flooding. In particular, Illinois, Minnesota and Wisconsin

have created State-level programs to fund mitigation activities.

10-l) The State floodplain management programs reviewed provide a good framework for regulating development within floodways and the 100-year floodplain. They do not provide guidance for the protection of residential and non-critical facilities located between the 100-year and 500-year flood elevations.

10-m) Federal agencies could be more efficient in responding to disasters and funding issues if standard procedures could be used, which would also provide a framework for State regulators to improve their programs as a group.

10-n) Floodplain managers believe there is much to be gained if existing Federal, State, and local rules and regulations concerning floodplain management, land use, and zoning requirements were followed, even without stricter Federal guidelines.

6). Do flood control projects induce development in floodplains? Are the effects of induced development properly accounted for?

BACKGROUND

A major concern shared by agencies, organizations, and interested observers in the aftermath of the Midwest flood of 1993 is the substantial amount of damage and other disruption costs and losses experienced by homes, businesses, public buildings and facilities, utilities, and the transportation network in locations that many assumed to be protected from extreme flood risk. Despite the expenditure of billions of dollars in flood control and protection works across the Nation over the past 60 years, and the demonstrated effectiveness of these works in preventing losses that have paid for this investment many times over, damages from major floods have continued to trend upward in real terms (see Floodplain Management in the United States: An Assessment Report, Vol. 2, 1992, pp. 3-18 and 3-19).

This situation has led many to question whether flood control works serve to induce people, businesses, and public services to locate in areas that remain subject to extreme flood events and that would otherwise be avoided if the flood protection were not in place. The concern is that instead of reducing society's vulnerability to flooding over time, structural flood protection projects may be inducing even greater exposure to the risks of extreme floods.

This discussion will not attempt to quantify or estimate the flood damages that might be attributable to induced development, with the exception of the reporting of a specific example (the Chesterfield Monarch levee in Missouri), but suggestions are developed that would require a more rigorous consideration of these potential losses in the planning and design of structural flood protection projects.

It must also be appreciated that there is an important historical perspective to be considered in examining the issue of induced floodplain development. Many communities in the Midwest were first settled based on their locations along rivers, and subsequent development was often inextricably linked to the commercial, transportation, and residential patterns with supporting infrastructure that were already established. There are economically rational explanations for that development and for why development pressures continue in floodplain locations. Problems result, however, when the residual flood risks associated with continued floodplain development, especially subsequent to completion of any flood protection project, fail to be recognized; when insurance protection or other self-protective "mitigative" actions are not taken; and when by default the Federal Government (i.e., the taxpayer) is expected to cover the complete disaster recovery bill for all major flooding.

It should also be noted that Federal flood protection projects are not usually designed for the primary purpose of encouraging expanded floodplain development; they are justified primarily based on expected future reductions of damage to existing development. There is recognition of Executive Order 11988, issued by President Carter in May 1977, which requires evaluation of the potential effects of Federal actions on floodplains and establishes a multi-step process for examining alternatives to actions that would have an impact on floodplains. Flood reduction benefits are not claimed, and projects are not justified, based on a projection of damages avoided to FUTURE development. (There are more conceptually complex procedures in the Federal water resources planning Principles and Guidelines that do allow "intensification" and "location" benefits to be claimed, but these are based on increased economic value of protected areas and not on damages avoided to development not yet present. These benefits are much less easily documented or accepted in the review of flood protection project proposals.)

Nevertheless, there remain important issues of how individuals and businesses in the private sector, as well as governments at all levels, perceive undeveloped and potentially redevelopable land within the protective shadow of flood protection projects, and how they act on those perceptions; how floodplains and flood risk are defined; and what can be done to improve recognition and avoid increased risks of flood damage that can accompany floodplain development decisions.

QUESTIONS FOR EXAMINATION

Among the questions that arise from a review of the literature related to the subject of induced floodplain development are these two:

What are the key factors creating incentives or disincentives regarding development in the floodplains?

How can the process of determining the appropriateness of structural flood protection projects, and the planning and design of such projects, be improved?

These questions will be considered in the discussion presented below.

DISCUSSION OF FACTORS INFLUENCING FLOODPLAIN DEVELOPMENT

There appear to be several causative factors at work that support continued floodplain development. Among these factors are: the perception of "protection" afforded by flood "control" projects; the absence of appropriate land use zoning and floodplain regulations, or enforcement of such regulations, especially at the local government level; and economic or social incentives (or lack of disincentives) which are not always recognized but continue to support development in floodplains. A common thread through all of these is that more education and understanding of flood risks are needed. Each of these factors will be examined in turn.

Structural Flood Protection

It is clear to many observers of floodplain management issues that flood protection projects do encourage additional development of floodplains. Flood protection projects include levees, floodwalls, and dams/reservoirs. They include Federal works but also those completed by other governmental or non-governmental entities, which are especially prominent in the construction of agricultural levees.

The Chesterfield-Monarch levee breach along the Missouri River west of St. Louis is a prime example from the 1993 flood of the extensive damage that can result when intensive development takes place in an area thought to be adequately protected by a levee. In this case, an existing agricultural levee was upgraded in the 1980's to provide protection for up to the 100-year flood, meeting the minimum standards of the National Flood Insurance Program, and industrial development subsequently took place behind the levee (Interagency Floodplain Management Review Committee, June 1994). Once this private levee failed, damages and other losses in excess of $200 million were incurred by some 250 commercial enterprises and related transportation facilities (Kansas City District, Army Corps of Engineers, September 1994).

Other reviews of floodplain development (Platt, 1986; Montz and Gruntfest, 1986; Holway and Burby, 1993) cite tendencies for communities to face intensified development pressures once flood control protection is provided. Even in communities where land use and floodplain management policies are actively pursued, pressures for continued floodplain development are often experienced (Burby and French, 1981).

There is also concern that, in situations where flood protection for critical facilities is generally viewed as necessary, care be taken to ensure that it is placed in such a manner so that other commercial or industrial development is not induced to locate nearby (R. Kucera, MO DNR, personal communication, 1994).

Another concern related to induced development is the situation downstream of dams, where floodplain areas perceived as adequately "protected" are developed despite the potential risk that remains from extraordinary flood events (Assessment Report, op. cit., 1992). The Association of State Floodplain Managers (1994) has advocated the need to maintain floodplain management practices in the hydraulic shadows of dams and behind flood control works in recognition of these residual flood risks.

These types of situations provide evidence that there is indeed a potentially powerful inducement for additional floodplain development associated with the construction of levees, dams and reservoirs, and floodwalls. While there is substantial documentation that these projects have functioned as intended (in the 1993 floods, an estimated $19.1 billion in damages were prevented), it is the negative side of the question, involving increased exposure to damage from induced development, that remains the concern.

What are the limitations of flood protection projects that need to be recognized as a response to large scale floods? The following shortcomings have been noted (Assessment Report, op. cit., 1992):

- levees, especially those built for emergency or agricultural purposes, are typically designed to provide protection only from smaller floods;

- not every earthen levee built with crown elevations equal to the design flood height can be expected to provide the anticipated protection due to changing hydrologic conditions and the possibility of failure before overtopping;

- internal drainage problems behind the levees, or backwater effects from main stem rivers on tributary streams, may continue as major contributing factors in causing damage.

These kinds of shortcomings were frequently experienced with non-Federal agricultural levees during the 1993 Midwest flood.

Problems identified with the Chesterfield Monarch levee include the lack of such refinements as underseepage relief wells, interior drainage systems, lack of pumping capacity, and need for an extensive maintenance program (Shepard, 1994). Black River Falls, Wisconsin, is another community that experienced extensive damage when a portion of a non-Federal levee washed out (Wisconsin DNR, 1993). These examples point to misperceptions and conceptual problems that are encouraged even by standards applied in the National Flood Insurance Program (NFIP). There is the notion that areas behind levees and floodwalls, or downstream of reservoirs, are essentially removed from the floodplain once the so called 100-year level of protection (or even greater) is built.

The reality is that these areas remain in the floodplain and continue to be vulnerable to flood risk if a truly extraordinary event occurs or if a protection system performs less than satisfactorily. Indeed, the Interagency Floodplain Management Review Committee report (June 1994) comments from the following perspective: "The residual risk to a building constructed behind a levee designed to provide protection from a 100-year flood is substantially greater than the risk to a building elevated to or above the 100-year flood elevation."

FEMA confirms that 24 percent of NFIP claims for the years 1978-1993 were for losses in zones B, C, and X, which are for areas outside the 100-year floodplain. Many of these losses are in areas with localized drainage problems which are too small to warrant the cost of floodplain mapping. These urban storm water management problems are really beyond the scope of the NFIP and are the responsibility of the individual community. Sewer backup may be caused by high groundwater resulting from heavy rainfall and not directly related to a general condition of flooding. Nevertheless, the number of claims submitted to cover these situations indicates that some people and businesses do recognize the potential for "flooding" at their locations even if they are outside or removed from a designated 100-year flood zone.

A related concern is that recently introduced "risk based" design approaches to structural flood protection projects may further exacerbate these problems (Association of State Floodplain Managers, 1994). A rigorous incremental analysis may conclude that protection to a 100-year or greater level for a given project is not economically justified, but protection of EXISTING development to a lesser height may be. The issue is that construction of lower levees may result in increasing exposure to catastrophic losses from extraordinary flood events unless the perception is altered that CONTINUED development behind such levees is safe.

At some locations, it may be worth the added cost to build a levee of less than standard project design with a wider than required foundation in the event that emergency action or a permanent levee raise needs to be pursued in the future. Levees can also be built, either at the upstream or downstream end, to overtop gradually to allow time for evacuation in the event of a flood in excess of the design of the levee.

In any case, it would appear that other steps be should taken, in combination with construction of a limited flood protection project, to avoid the potential for unsafe development. This means an end to the mentality, where it may exist at the local level, that once a community has a structural flood control project, no flood problems should ever again be experienced. If a greater level of flood protection is desired than what is determined to be economically feasible, a local community has the option of adding to the height of a levee or floodwall at its own expense.

A more effective response to the potential for flooding problems requires attention on the part of all parties, both public and private sector, of the residual risk that remains even after completion of a project. If NEW development does not REQUIRE location in the floodplain area now being protected, it would be prudent to locate it elsewhere. If it is determined that the "protected" floodplain is the best place to locate, then the added costs of elevating the structure, floodproofing the structure, or otherwise modifying the use of the structure should be factored into the development decision.

A reasonable goal would seem to be that FUTURE development be designed and built to meet at least the minimum 100-year flood level on its own merits at the development site, even after a limited flood protection project is completed. This approach is not trouble free itself, in that facilities run the risk of being isolated or inaccessible when a major flood surrounds a building, even if the building itself is not damaged. Nevertheless, this step would go a long way toward changing the perception that, once a limited flood protection project is in place, it is safe to intensify the development behind the levee or downstream of the dam. It would also reduce the risk of catastrophic losses if a flood in excess of the design of the levee or reservoir occurs.

If the additional costs of safely developing in floodplain locations behind a levee or downstream of a dam are too great, then it suggests that alternative uses of the floodplain not subject to substantial damage should be considered, and the more intensive development that could be exposed to severe flood damage should be located elsewhere.

Floodplain Land Use Zoning

Another view widely shared by floodplain management specialists is that more stringent land use zoning policies in floodplains by local governments is needed to ensure that exposure to flood problems is reduced. If appropriate zoning policies are properly enacted and enforced, there would be much less need for structural flood protection and much less concern about induced development. In Illinois, for instance, only 53 of 102 counties have zoning in place (Interagency Hazard Mitigation Team report, FEMA-997-DR-IL, 1993).

This approach is most effective if it is applied in advance of pressures to develop potentially vulnerable areas that are currently undeveloped. Once the land is acquired and plans are underway to develop the property, local communities appear to be generally much less able or willing to prohibit the development from proceeding. The best that may be able to be achieved is the imposition of floodproofing or elevation requirements in conjunction with the development (Burby and French, 1981). Once the development is in place, it is too late for zoning to work as a flood damage prevention tool.

After the floodplain development is in place, a real test for determining its long-term economic viability is a willingness to continuously carry actuarially sound flood insurance to protect structures from the risk of loss to flooding.

There are other obstacles from the perspective of local communities that need to be recognized in applying zoning restrictions as a means of avoiding induced development behind structural flood protection projects and exposure to damages from flooding. In many cases, there is a concern the floodplain zoning incurs detrimental impacts, such as reduced land values, reduction in community economic growth and development, reduction in the tax base, and increased construction costs (Burby and French, 1985). Although research on these questions is not conclusive, there is some evidence that structural flood protection may marginally increase floodplain land values, while requirements to elevate structures above the 100-year flood elevation will tend to reduce land values (Holway and Burby, 1990).

A related concern, not so much attributable to planning and zoning for future development but in responding to flood problems for existing development, is the propensity for affordable housing to be disproportionately located in flood prone areas (Review Committee, op. cit., 1994). This point may be especially important in the implementation of flood hazard mitigation strategies involving buyouts of substantially damaged or repetitively damaged residences, where the real cost of pursuing the strategy of avoiding exposure to flooding should consider not only the purchase price of the properties but also any additional expense of relocating people to safe yet affordable alternative housing. This approach may still be worth pursuing in a large number of cases involving repetitive flooding if the future social costs, emergency response, and disaster relief costs can be eliminated. Residents in areas of repeat flooding should not consider this as an "entitlement," however, because Federal disaster declarations will not be issued for every flood event, especially if the event is localized. Residents and their communities maintain a primary responsibility for addressing problem areas afflicted by frequent flooding.

Communities can accelerate development in areas at risk of flooding through the extension of municipal services. The Interagency Hazard Mitigation Team Report for Illinois (FEMA-997-DR-IL, 1993) comments that, although there has been ongoing acceptance of community development in floodplains in Illinois, the availability of infrastructure is a major incentive. The construction of levees and establishment of local drainage districts can create a false sense of security to the threat of floods. Adoption and enforcement of building codes, such as finished floor elevation requirements, is an alternative to be considered in these circumstances.

These concerns suggest from several perspectives what is probably the fundamental issue for many people with regard to floodplain development, that being how best to ensure that the "beneficiaries" of flood protection projects and the users of floodplain locations also recognize and assume responsibility for the risks associated with these locations. Land use zoning and regulation may inhibit opportunities that appear economically advantageous, but they also function to avoid the externalities (costs) of flooding and recovery that may not be properly recognized in the original investment decision and for which the general population through their governments are too often being asked to assume. Because local units of government have responsibility for land use zoning and regulation, it is important that they recognize the potential costs of flooding as an important factor in land use planning and zoning decisions. Many development decisions are not black and white, all or nothing. Often there are alternative sites or alternative strategies that can be employed to further the economic development of a community in a manner that does not increase the risk of damages from flooding.

Economic Incentives and Disincentives

Although it can be argued that relative flood losses in comparison with the national economy have not increased over time, property losses and other economic losses have generally trended upward even in adjusted dollar terms due to population growth and continued development of floodplains. This has occurred despite the numerous structural projects and nonstructural policies implemented to reduce flood damages (see Assessment Report, op. cit., 1992, pp. 3-34 to 3-36 for discussion of relative flood losses). Another perspective would suggest, however, that flood losses would have grown very much higher without the structural and nonstructural measures that have been taken to reduce flood damages.

One explanation for this upward trend in flood losses, already noted, is that private land use decisions are significantly affected by the public investments made in infrastructure, including flood protection works. To the extent that these publicly borne costs make private investment decisions more profitable, more development may be taking place in potentially vulnerable areas than would otherwise be the case. This may especially be happening if environmental and social costs related to flood risk and natural resource degradation are not accounted for (Stavins and Jaffe, 1990).

An example of how this can work is reflected in the results of a survey completed of property brokers in the Chesterfield Valley after the 1993 flood. Property values were generally recognized as having declined by 30 percent or more in the aftermath of the flood. If the levee were restored to its preflood 100-year level, most believed that property values and rents would still be 10 to 30 percent below the preflood value. However, if the levee protection were increased to the 500-year level, it was felt that preflood values would be restored (Shepard, 1994).

The availability of flood insurance and the expectation of flood disaster aid in response to catastrophic flooding may also serve to encourage continued floodplain development (Holway and Burby, 1993). Perhaps even more important, however, is the removal of areas adjacent to or behind the designated 100-year flood zones from flood insurance requirements. This encourages a perception of an area "safe" for development, but where the risk of severe losses to extreme flood events remains. The low number of flood insurance policies in force for properties behind the Chesterfield levee at the time of the 1993 flood is evidence of this pattern.

It may require disincentives to discourage building in flood-prone areas. This may take the form of tax code adjustments or the imposition of construction requirements that add cost to the decision to invest in an area of flood risk. Alternatively, tax breaks or other kinds of financial assistance can be offered to encourage development in areas free of flood risk. The challenge, either way, is to anticipate the residual economic, social, and environmental costs that accompany investment in areas subject to flood risk, and the avoidance of these costs that can be realized by developing at alternative sites.

The issue that needs to be confronted from this discussion is that development decisions which continue to focus on "protected" floodplain locations suggest that there is a willingness to incur damages when extraordinary flooding occurs. For those floodplain locations where complete "avoidance" is apparently not the economically rational strategy, either flood insurance or other kinds of adaptable, mitigative actions must accompany the investment to ensure its independent, unsubsidized economic viability. This means that there should NOT be great surprise when the damages associated with extraordinary floods occur.

From the 1993 Midwest flood experience, however, it can be observed that flood risks continue NOT to be well recognized or understood, and that significant flood damages are NOT readily accepted. The bottom line, then, is that individuals and society as a whole cannot have it both ways; i.e., maintaining that development in floodplains is economically viable in a variety of ways and locations and yet seeking outside financial assistance when the extreme flood event strikes. All flood risks cannot be cost effectively prevented, and all new floodplain development cannot be prohibited without an increase in development costs in many instances. So the question remains: how do we (individually and collectively) make better decisions on how we use (or not use) floodplain lands, and how do we (individually and collectively) best cover the residual risks that remain?

IMPROVED ACCOUNTING OF THE EFFECTS OF INDUCED DEVELOPMENT

If there is acceptance of the possibility that flood protection projects can induce more development than would otherwise be the case in areas of residual flood risk, what can be done to ensure that such development is accounted for in the decision-making process?

Any proposed structural flood control project, or improvement or expansion of existing projects, needs to explicitly account for the following potential detrimental impacts:

a) induced damages either upstream, downstream, or across stream of the project site as a result of whatever hydraulic changes can be anticipated with completion of the project;

b) residual damages at the location of the project site, given that flooding beyond the level of protection being provided is still a possibility;

c) if plans are known, or possible, that would involve more intensive use of the protected site, the implications of residual risk for the induced development should be recognized and quantified as an important factor in the project formulation process;

d) the annual and long-term costs, including monetary and staff resources, of maintaining and repairing the flood control project should be fully recognized and quantified; and

e) any additional costs that should be expected by the businesses or residences to be located in the area behind the flood protection project to anticipate and respond to the residual flood risk should also be recognized and quantified, such as: any elevation requirements for construction of new structures in "protected" areas; floodproofing actions that may continue to be desirable; flood insurance requirements; or costs for responding to flood emergencies or disruptions.

Existing analytical procedures, as spelled out in the Federal water resources planning Principles and Guidelines, formally cover these issues, or at least allow for their consideration. It is clear, however, that the focus of analysis in formulating plans for the reduction of flood damages has been largely devoted to estimating benefits to be obtained from the reduction (but not elimination) of exposure to flood damages through the construction of flood protection projects.

If more attention were routinely devoted to the factors identified in a. through e. above in the evaluation of flood protection proposals at the Federal, State, and local levels, a better understanding would be achieved of all of the ramifications associated with the construction of these projects. As a result, other approaches to flood damage avoidance could, in some cases, be more seriously considered. In other cases, it might lead to consideration of an even greater level of protection, given a better understanding of the potential for substantial losses if a levee is overtopped.

There are other steps, from a regulatory perspective, that can also be taken to improve the accounting for potentially induced development. One concept is to expand the definition of flood risk to include areas protected by levees from the 100-year flood, and to encourage or compel flood insurance coverage for structures in these areas. Current practice is for communities to petition the Federal Insurance Administration for removal of previously floodprone properties from flood insurance requirements once a levee is in place that protects from a 100-year flood (Interagency Hazard Mitigation Team Report, FEMA-989/995/1006-DR-MO, 1993). Once the insurance requirements are lifted, it serves as an invitation for additional "safe" development to take place. Some community development plans obviously have been designed to achieve the minimum level of protection necessary to gain removal of flood insurance requirements and then to promptly allow new or more intensive development of these areas.

Instead of completely removing such areas from flood maps and flood insurance requirements, the maintenance of a flood risk zone designation in the flood insurance program for areas behind levees would serve as an important reminder of residual risk that remains. The recommendation from the Hazard Mitigation Team Report is that a separate floodplain zone designation should be applied to areas behind levees meeting Federal standards, and that flood insurance should be offered to property owners in this zone. If properties in these areas are being acquired with federally backed mortgages, then there should continue to be mandatory flood insurance purchase requirements. The premiums would presumably be scaled to reflect the reduced risk of flooding in this zone.

The expectation is that if this insurance coverage requirement was implemented, less economic distress would be experienced and less disaster aid would be needed when levees meeting Federal standards are overtopped. This approach addresses the reality that 30 percent or more of flood insurance payouts are already being made in areas beyond designated 100-year flood zones, and that the statistical odds of a greater-than-100-year flood occurring in any given area over a 30-year period is about 1 in 4. This concept is endorsed as Action 9.6 in the Interagency Review Committee report (1994) as well.

This approach is also responsive to the reality that hydrologic conditions do change over time, given development which takes place in other areas of a watershed outside of the floodplain itself. Conversions of land use, especially from previously natural conditions, can cause changes in runoff patterns if upland watershed retention measures are not pursued. An estimate of the relationship between flood flows and flood stages can be developed based on historical records, but this relationship cannot be considered as permanently fixed, especially in areas where historical records are limited or significant development in a watershed takes place over time. All of this is to indicate that the designation of a 100-year flood zone, or the construction of a levee to provide "100-year" level of protection, is a line on a map or an elevation in the midst of a gradation or range of possible flood conditions. It should never be taken to mean that a structure just outside a designated line on a map is eminently safer from flood risk than a structure just inside the designated line, or that once a "100 year" levee is built that the area behind the levee is freed from future flood problems.

SUMMARY

This review finds that the potential for flood control projects to induce development in floodplains is significant, especially in areas that have not already been fully developed, and that the effects of induced development are frequently not well recognized or well accounted for.

At least three different approaches can be fashioned in responding to the pattern and consequences of induced development. They do not have to be considered as mutually exclusive, but there are clear differences in emphasis. It may also be useful to think of each in terms of the relative degree of responsibility that is exercised by government at its various levels, and by the private sector (i.e., businesses and households), in considering how issues of induced development are dealt with and associated flood problems are addressed.

One approach is basically a continuation of a historical pattern which suggests that more intensive uses of floodplains will continue; that damages associated with extraordinary flood events will grow; and that Federal emergency response costs and disaster relief payments will be primary response mechanisms, assisted by flood insurance programs. This approach suggests that the existing mixture of policies, programs, incentives, and projects works reasonably well, and that the economic damages and social impacts associated with large scale floods can be tolerated and paid for by society as a whole.

Another approach attaches a much greater importance on modifying existing policies, programs, and incentives in ways that will strongly encourage either the avoidance of new development to flood risk or the protection against flood losses through much stronger insurance requirements. Elements of this approach could include an expanded definition of flood risk and an expanded national flood insurance program; more rigorous floodplain management and flood hazard mitigation requirements by many State governments; more rigorous land use and zoning requirements by local governments; and more responsibility on the parts of homeowners and businesses to continuously carry flood insurance to cover the risks of being in or choosing to locate in an area potentially at risk of flooding. First-floor elevation requirements, or site designs achieving a minimum 100 year elevation for new development, are specific tools to be considered in reducing the risks of flooding, even if limited flood protection projects have been completed.

A third approach is also to recognize the pattern of induced development and to fully incorporate this possibility in the design of structural flood protection projects. This could mean adding a higher level of protection than would otherwise be considered to account for the increased risk of catastrophic losses that could occur if more intensive development takes place subsequent to the completion of a limited structural protection project. This approach emphasizes that the potential for additional damages to induced development is not being fully recognized in the design of more limited flood protection projects, and that the preferred response is to provide incremental added protection. The added costs of building even higher levels of flood protection are currently assumed by the local sponsor of a Federal project, and this policy would be expected to continue.

Regardless of the approach, it is certain that detailed analysis, both site specific and systemic, would help to clarify the economic, social, and environmental trade-offs that accompany decisions to pursue development in floodplains. The concern about induced development suggests that, with improved recognition and understanding of the potential problems associated with floodplain locations, there would be fewer instances of new development being pursued in areas that remain at risk of flooding, even with limited structural flood protection being provided. It may be that increased development costs in other than floodplain locations are an acceptable trade-off in order to avoid the potential for future damages associated with extraordinary flooding. Said in another way, a lower cost of development that is achieved through a floodplain location may not actually be less expensive once the potential for damages associated with the site is fully considered.

The economic trade-offs involve choices between a) acceptance of large amounts of damage associated with extraordinary flood events; b) acceptance of added costs associated with development in safe locations away from floodplains; or c) acceptance of added costs associated with providing increasing levels of structural flood protection. The lessons from the 1993 flood appear to be that a) the first choice is not acceptable; b) the second choice should be strongly considered for any new development; and c) the third choice is worthy of consideration in areas already intensively developed that are not already protected from extraordinary flood risk.

FINDINGS:

10-o) Past Federal actions to insure or provide disaster assistance for vulnerable floodplain locations have contributed to more intensive use and subsequent exposure to flood damages than would otherwise have been the case.

10-p) Structural flood protection projects have tended to induce floodplain development beyond what otherwise would have taken place, and the effects of such inducement have frequently not been well accounted for. In most areas, however, development preceded the installation of flood protection works. The Principles and Guidelines for Federal water resources planning permit a detailed examination of the effects of induced development.

10-q) More comprehensive economic evaluations in flood control studies would help to explicitly address the benefits and costs associated with development in floodplain locations. A rational system of floodplain management would require new activities in floodplain locations to: a) self-cover all losses that will be incurred when a flood strikes, or b) pay for flood insurance on a continuing basis to cover such losses.

10-r) Exposure to risk in the floodplain, and associated flood damages, is now too often considered as an "externality," a cost that society is asked to pay when the "unexpected" flood strikes. Unless those who invest and locate in the floodplain are able to assume the costs of flood damages themselves, or insure against these risks, the rest of society (i.e., government and taxpayers) is subsidizing potentially unwise investment decisions.

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7). What are some measures that could be taken to provide more sophisticated river modeling?

The Corps of Engineers did not have an integrated river model or method specifically designed and set up for the Mississippi River to analyze and predict system-wide impacts of various alternative actions during large floods such as were experienced on the Mississippi River during the summer of 1993. Although reservoirs were effectively operated during the 1993 flood, improvements are necessary in the prediction of runoff, reliability of stage forecasts during extreme events, analysis of the impacts of actual or probable levee failures (both locally and downstream), and communications between Corps offices, other agencies and with Corps customers.

The Interagency Floodplain Management Review Committee, in its June 1994 report to the Administration Floodplain Management Task Force, also addressed the need for a system-wide unsteady flow model of the Mississippi and Missouri Rivers. One-dimensional steady state models that existed during the 1993 flood are unable to satisfactorily model the complex condition of flow where water moves into large storage areas in the overbank floodplain. They went on to state that a "system-wide, unsteady flow model of the main stem rivers in the upper Mississippi River Basin would evaluate the impacts of proposed structures and floodfighting, and could be used for coordinated ecosystem modeling, and for floodplain management decisions." The UNET model is the unsteady state modeling program being used to meet this need. It is capable of accounting for storage in the overbank portion of the valley cross section.

The Corps began development of upper Mississippi River and lower Missouri River UNET models for water control purposes in 1994. To obtain the necessary hydraulic stage comparisons for the alternatives being analyzed in this assessment, the FPMA supplemented this separate modeling effort and this effort was accelerated for the FPMA, especially in the Rock Island and Kansas City Districts. UNET models of the Mississippi River from St Paul, Minnesota, to Cairo, Illinois, and of the Missouri River from Omaha, Nebraska, to St Louis, Missouri, have been developed. These models have been calibrated to the 1993 flood conditions, and were used to model various action alternatives for the Floodplain Management Assessment. Further refinement and development will continue in future years to address Water Control Operation needs for operation of the Corps of Engineers projects and to provide support to the National Weather Service in its role of river forecasting. The existing models are based on existing mapping. The modeling was appropriate for this assessment, but additional mapping, especially landward of existing levees, would be needed to more accurately determine flow capacities and stages.

<u>FINDINGS</u>:

10-s) The Corps of Engineers has now developed UNET models of the Mississippi River from St. Paul, Minnesota, to Cairo, Illinois, and of the Missouri River from Omaha, Nebraska, to St. Louis, Missouri. Further refinement of these models and extending them to critical river reaches not yet modeled will require significant additional basic data.

10-t) The FPMA modeling has shown that some changes on the Mississippi and Missouri Rivers have system-wide effects. The UNET model is an appropriate tool to analyze these effects.

8). Are levees considered to be part of the navigation system?

MISSISSIPPI RIVER

Levees may be considered to be part of the navigation system in a limited set of circumstances. The 9-foot channel project on the Mississippi River consists of a series of locks and dams to create pools to provide reliable water depths for navigation. Flood control levees were not constructed as part of the 9-foot channel project. However, levees were used to tie off locks and dams instead of natural high ground in some cases.

There are some instances where flood control levees may encroach upon areas that would otherwise lie within the flat navigation pool. This could occur in either mid-pool areas or at the site of a lock and dam.

In mid-pool areas, flood control levees are not necessary to maintain the navigation pool. An encroaching flood control levee takes the place of the natural bankline. Without the flood control levee, the water would revert to the natural bankline.

At lock and dam sites, the pool is maintained by Federal structures which tie into high ground. "High ground" may be a natural or man-made land feature. During the establishment of the 9-foot channel navigation project, each location was evaluated and structures necessary to maintain the navigation pools were constructed. These structures are maintained by the Corps of Engineers. No additional structures are currently needed to support the 9-foot channel navigation project.

MISSOURI RIVER

Authority for the Missouri River Bank Stabilization and Navigation project is distributed throughout a long list of legislation beginning in 1912. When the 1944 Flood Control Act created the Pick-Sloan plan for comprehensive basin development shared by the Corps of Engineers and the Bureau of Reclamation, both the bank stabilization and navigation improvements were assigned to the Corps of Engineers. The Pick-Sloan Plan also included the Missouri River Levee System to control floods in combination with upstream multiple-purpose lakes. The same structures used to maintain the authorized depth and width for navigation simultaneously stabilized the banks by establishing revetments and closing chutes. Levee builders benefited from the stable banks, and the bank stabilization project benefited from levees that prevented high flows from returning to old channels. Still, the flood control levees and bank stabilization works remained separate in terms of construction and maintenance.

With regard to the continued operation of the navigation system, the answer to the question, "Are levees considered to be part of the navigation system?" is a definite and emphatic NO. Nevertheless, some training structures (levees, dikes, groins) are essential to the bank stabilization program, particularly at tributary confluences and at closed chutes. At intermediate flood stages, these structures may act as levees. Regardless of the design or intent of these structures, some floodplain residents have come to view them as flood protection.

The various configurations of dikes, sills, and revetments in the lower Missouri River support control and development of the navigation channel. They are exclusively hydraulic controls for maintaining the authorized depth and width. In contrast, levees can be beneficial or detrimental to the operation and maintenance of the Missouri River's control structures.

Flood events like the 1993 flood suggest that the levees that failed were a liability. When a levee overtops and ultimately breaches, blowouts, scour holes, chutes and cutoffs across meanders may develop, aided by the sudden release of flow into the area behind the levee. The degree of damage to the river structures depends on several variables. After a large flood, considerable maintenance, time and funds are required to re-establish the integrity of the system. During more frequent floods, where no hydraulic failure of a levee occurs, the levees prevent blowouts, cutoffs across meanders or chute development. Typically, flood events of lower magnitude and stage, confined by local levees, cause less damage to the river's structures and pose only a minimal threat to its operation and integrity.

The lower Missouri River is an aggressive and dynamic water conveyance system. Its recent history indicates that the channel has migrated from one bluff line to the opposite bluff line near White Cloud, Nebraska, approximately 13 miles, during a period of less than 24 hours. Channel shifting of a few hundred yards overnight is repeated in many historical documents. This shifting appears to be a common characteristic of the sandy bed and banks. Prior to bank stabilization, this channel shifting pre-empted any long-term use of the Missouri River, its water supply, or its floodplains for economic development or benefit.

For nearly eight decades, attempts have been made to train, stabilize, and control the river in a usable alignment. The river's channel, its floodplains, and the infrastructure around the stabilized channel were severely tested by the 1993 flood. Damage to the river's control structures due to yielding and failure of levees was considerable. Between 150 and 175 scour holes or blowouts developed along with 25 potential channel cutoffs. But as the flood receded, the river remained along its present aligned course. Without river control structures, the risk to economic or infrastructure development would carry a high cost to the taxpayer.

<u>FINDING</u>:

10-u) Levees may be considered to be part of the navigation system in a limited set of circumstances. However, during the establishment of the 9-foot channel project, each lock and dam site was evaluated and structures necessary to maintain navigation were built, and are currently being maintained, by the Corps of Engineers.

9). Evaluate the impact navigation projects have on flooding, including the effects of sedimentation?

BACKGROUND

It has been suggested that the navigation projects on the upper Mississippi and lower Missouri Rivers cause an increase in water levels during floods. The perception is that: (1) the pools created by the navigation dams induce sedimentation which reduces channel capacity; and (2) navigation dams and channel training structures restrict the natural floodway, causing an increase in water levels during floods.

UPPER MISSISSIPPI RIVER

Sedimentation

It is well known that the Mississippi River transports a massive volume of sediment each year. Much of the sediment remains in suspension and is transported downstream to the Gulf of Mexico. However, at any location where a reduction in velocity occurs, the river's sediment transport capability is reduced, resulting in sediment deposition. This is a dynamic process which occurs in both natural rivers and those that have undergone changes induced by humans. Some suggest that deposition of sediment in the navigation pools of the upper Mississippi River has reduced the capacity of the river to convey water during flood events. The following discussion addresses this issue.

Sediment deposition in the navigation pools occurs in both the main channel and backwater areas of the pools. However, the sediment transport process and characteristics of the material deposited are distinctly different. Because the majority of river flow is concentrated in the main channel, the sediment transport capacity is also greater. Most of the fine-grained sediments suspended in the water column will continue to be transported downstream. Deposited sediment consists of primarily coarse-grained, sandy material, referred to as bedload. As long as sufficient energy is available, deposition of sediment will be limited and the transport process will continue. However, when conditions are encountered that either reduce velocity or modify flow patterns, i.e., changes in channel geometry such as bends or meanders, structural obstacles, or a reduction in river flow, deposition will occur. Generally, deposition at one location in a cross section is balanced by erosion at another. For example, at bends or curves in the river, it is common to see sediment deposition on the inside of the curve and erosion on the outside of the curve. This is due to secondary currents transverse to the main direction of flow. Erosion also occurs during flood events. The steeper slope of the water surface leads to an increase in velocity, which causes the channel to scour. Because of the dynamic nature of the sedimentation process, net sediment deposition in the main river channel is minimal, although large variations in sediment deposition can be observed locally. Evaluation of survey data collected in pool 20 by the Iowa Institute of Hydraulic Research supports this conclusion. Comparison of river cross sections surveyed in 1937 and again in 1950 shows an estimated average deposition rate of 0.1 inch per year.

In contrast to the main channel, sedimentation in the backwater areas of the navigation pools is limited to primarily fine-grained sands and silts. Instead of being transported as bedload along the bottom of the river, these finer sediments are transported as a suspended load which is distributed more or less uniformly throughout the water column. During low flow periods, velocities through these areas may approach zero as the areas become disconnected from the main river. Because there is insufficient energy available to keep the material in suspension, deposition occurs. However, as in the case of the main channel, the net rate of sediment deposition is very low. Survey data collected along transects established and monitored by the Environmental Management Technical Center in the backwaters of Mississippi River pools 4, 8, and 13 illustrate this. Net sediment accumulation over the three pools studied in

1989-1993, just prior to the 1993 flood, was on the order of 1 to 2 cm. per year. Survey of the same cross sections following the 1993 flood showed a decrease in the net rate of accumulation. Along many of the transects, erosion was the dominant feature.

In summary, sediment deposition does occur in the navigation pools of the upper Mississippi River. However, although large changes in bathymetry may be seen locally, the average net change in cross sectional area through the pools is negligible. Therefore, conveyance of floodwaters is unaffected.

Navigation Dams

The manner in which navigation dams are operated is also believed to have an impact on flooding. On the upper Mississippi River, there are 29 navigation locks and dams that create a series of pools on the river. During low and normal river flows, the gates of the navigation dams are operated so as to maintain a minimum 9-foot channel while passing the natural river flow downstream. A limited amount of water is stored to meet that objective. As the flow in the river increases, the gates of the dam are opened accordingly so as not to exceed a prescribed pool stage at the dam. At such time that the water level downstream of the dam is nearly equal to the water level upstream, the gates of the dam are completely raised out of the water, allowing the river to flow without restriction. The effect of the structure on water levels once the gates are removed from the water is minimal. At most of the navigation dams within the Rock Island District, a swell head of less than 0.5 foot can be observed locally in the vicinity of the dam.

A related question is whether any benefit could be obtained by opening the gates of the navigation dams in advance of a predicted flood. In general, the volume of water that would be evacuated by raising the gates of the dam earlier than the current practice is minuscule compared to the volume of runoff entering the system during a major flood. In 1969, the Rock Island District contracted with the University of Iowa Institute of Hydraulic Research to quantify how much, if any, reduction in flood crest could be gained by taking the navigation dams out of operation earlier. Computed profiles and hydrographs for Mississippi River pools 14 and 15, which were representative of a modified operation, were compared with observed profiles and hydrographs of the 1965 flood. Results of that analysis showed that, for floods with peak discharges in excess of 200,000 cfs, raising the gates of the navigation dam out of the water in advance of a flood event produced absolutely no reduction in peak stages. For smaller floods with peak discharges less than 200,000 cfs, reductions of 0.1 to 0.4 foot could be realized, depending on the location within the pool and the distance from the dam.

Channelization

Wing dams and other channel training structures used to stabilize the channel are also thought to cause increased water levels during floods by obstructing flow and decreasing the width of the floodway. On the Upper Mississippi River, wing dams and cross dikes are submerged structures which have an effect only during low flows. During low flows, these structures produce a localized increase in velocity to discourage sediment accumulation in the navigation channel. During floods, these structures are submerged by as much as 10 to 20 feet of water and produce no increase in water levels or velocity.

LOWER MISSOURI RIVER

Due to the complexity of the issue, it is not possible to conclusively address the effects of channelization on flooding along the lower Missouri River within the scope of this assessment. The navigation channel on the Missouri River is maintained by a combination of sills, cross dikes, and revetments which extend into the river from the natural high ground. While it is agreed that channelization has reduced the width of the floodway, the effects of that reduction are in dispute. Although the floodway is narrower, the river flows at a greater depth. It can theoretically be shown that a deep, narrow channel will convey more flow than a wide, shallow channel. Stabilization structures, however, armor the channel, limiting the river's ability to expand as a natural channel would during flood events. Further, sedimentation which has occurred between dike structures has encouraged the colonization of willows. This restricts the natural floodway and decreases conveyance. It should be noted that the Kansas City District is seeking additional funds to evaluate the impact navigation and bank stabilization structures have on flood stages.

<u>FINDING</u>:

10-v) Sedimentation in backwater areas, navigation dams, and channel training structures do not have an impact on flooding on the upper Mississippi River. Channelization along the lower Missouri River needs to be studied in greater depth in order to conclusively determine its effect on flooding.

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CHAPTER 11 - DESIRES OF AFFECTED INTERESTS

Identifying and Arraying Desires of All Interested Parties

The Public Involvement Work Group designed its program to meet the study objectives, particularly Objective B: Identify and array the desires of all interested parties within the study area to reflect the diversity of opinions regarding appropriate future outputs from alternative uses of floodplain resources; and Objective F: Evaluate and prioritize alternative land and water resource actions based on consultation and coordination with affected Federal, State, and local entities through a series of public workshops or similar mechanisms.

Identifying and arraying the desires of interested parties within the study area was done to ensure that the assessment reflects the diversity of opinion regarding the alternative uses of floodplain resources. The public involvement strategy was based on two definitions: 1) All potentially affected individuals, agencies, organizations and interest groups; and 2) Involvement was characterized by the nature and extent of the public's participation in problem solving and decision-making.

Public Involvement Strategy

Part I: Public Meetings and Workshops

In order to accomplish the above tasks, the Public Involvement Work Group decided on a series of public workshops/open houses and evaluation meetings with local, State, and Federal agencies. Participation by the public was considered extremely important in the assessment process to increase credibility and public support. Public input was also obtained from written correspondence and comment sheets.

Three sets of public meetings and workshops were designed to inform the public and to identify interests, issues of concern, needs, constraints, opportunities, and desires. The first set, held in June 1994, was designed as an open house, to inform and educate the public about the Floodplain Management Assessment (FPMA) and to obtain information from them. The second set, held in November 1994, was designed to present information, followed by comments and concerns from the audience, with a request for written comments. The third set, held in April 1995, was designed to educate the public by providing the findings and conclusions from the FPMA draft report and obtain their priorities for policies/programs and action alternatives. The April meetings were particularly difficult to prepare for, because complex information needed to be sorted out and presented to the public in a simple, understandable way. To do this required knowledge of how to get information across to the layperson: There are "two basic human needs for information - making sense and involvement." These two needs are defined as follows: (1) making sense - coherence of the information, and (2) involvement - complex information "places very high processing demand on the observer" thus requiring more involvement (Gimblett, Itami, Fitzgibbon, 1985).

An initial "Think Tank" meeting was held with agencies, organizations, and interest groups in February 1994 to identify the issues and define strategies for the assessment.

Interagency team workshops with local, State and Federal agencies took place during February 1994, August 1994, October 1994, January 1995, February 1995 and May 1995.

Part II: Master Mailing List

A master mailing list was developed from all five Districts, consisting of Federal and State agencies, organizations and interest groups that had shown prior interest in the subject of floodplain management. The St. Paul District maintained the master mailing list in order to avoid sending duplicate mailings. The master mailing list, of approximately 200, was used to distribute the milestone packages, notices of public meetings and other information. Each District also used supplemental mailing lists to include others who were interested and requested information about the Floodplain Management Assessment.

Part III: Milestone Packages

Three milestone packages were prepared and distributed to Federal agencies, State agencies, organizations, interest groups, and interested individuals. The first milestone package (Existing Condition Identification Summary) was sent on August 5, 1994 to provide an update of the work being done on the FPMA. Recipients were encouraged to review the data and offer guidance on revised directions, additional sources of information, or general comments for consideration. The second milestone package (Problem/Issue Identification) was sent on September 15, 1994 as a further update, and recipients were again encouraged to review the data and offer guidance, direction, or comments. The third milestone package (Alternatives Identified and Developed), completed January 18, 1995, was also provided as an update, with continued encouragement to review the data and offer comments. Questions expressed at the public meetings in November 1994 and written comments received through December 1994 were responded to in the third milestone package. Several refinements to the study were made as a result of the comments received.

Part IV: Institutional Analysis

Just as the focus of the FPMA study explored the systemic nature (whole system) of floodplains during the 1993 floods along the Mississippi and Missouri Rivers, so too the focus of the Public Involvement process required a look at the whole body of potential individuals, agencies, organizations, and interest groups. The institutional analysis was considered an extremely important part of this process. It served as a valuable tool in understanding, evaluating, and analyzing the institutional setting (legality and compliance, political conflicts, social and cultural values, and administrative effectiveness). "In our complex world, decisions which impact the public interest require complex coordination between all concerned interests, and due consideration of the legal and economic factors, political feasibility, and examination of the powers and authority of public bodies which are charged with responsibility for the public interest" (Soyke, 1980). Political interaction from individuals, groups and organizations is necessary for consensus building. Opposition interests which fail to show up at public meetings may surface later to stall implementation.

Chapter 2 of this report begins to analyze the floodplain forces by providing a historical evaluation of the study area, an institutional inventory, and policy and program introduction. The institutional inventory is a list of institutions, organizations and groups (see Appendix D for the list). The inventory list is only the first step in gathering data for the analysis. Because of the interrelated complexity of an institutional analysis, along with the cost and time required for the analysis, it was considered beyond the scope of the FPMA study. An unbiased, comprehensive institutional analysis would be necessary to fully understand and prepare for a new floodplain approach that would be supported. This would aid in reducing possible problems or preparing ahead to confront them.

An evaluation is necessary to understand how differences in floodplain management will affect individuals and groups with different political systems. Conflict is unavoidable, but conflict between interest groups and agencies, as well as interagency conflict, needs to be identified and opened for discussion. Better coordina-

tion is important, but it is not the sole answer in reducing conflicting agency goals, missions, bureaucratic inertia, and turf battles that prevent public agencies from effectively cooperating to protect complex river systems.

The success of any change in floodplain management will depend on gaining support from local communities and citizens, since most floodplain land use is decided by local policy. Local communities must be actively engaged in efforts to work together to manage the health of the floodplain system. Communities, especially floodplain landowners, perceive the loss of jobs and economic productivity and are reluctant to change, but communities potentially stand to gain the most from improvements that generate economic and community development opportunities (improved water quality and supply, improved recreational/fishing/hunting opportunities, improved aesthetics and land values, etc.). River-focused community revitalization projects work with bottom-up local involvement. Local communities will need support in making floodplain changes to maintain economic vitality, but it will require local empowerment, effective new incentives, the removal of disincentives, and effective implementation structures.

1993 Flood Impact on River Communities

Before the Great Flood of 1993 arrived, communities were dealing with major problems involving old infrastructure issues, and social and economic change. These issues and changes were accelerated due to unprecedented damage from the floods. Tough planning issues that needed to be dealt with quickly included: "resolving housing shortages, finding suitable sites for subdivisions and towns, finessing the financial resources to implement projects, building the necessary infrastructure to accommodate growth, and reusing cleared floodplain lands" (Morrish, Swenson, Baltus, 1994). The recovery process is far from over. "While the floods and the recovery process are felt most immediately in the community, their regional and national importance will only become more apparent with time. From a preliminary needs assessment study of post-flood recovery planning issues at the community level, we can draw conclusions that have implications at the larger scale" (Morrish, Swenson, Baltus, 1994). Very little money has been made available to communities to plan for relocation, while millions were spent to acquire flood damaged properties. A very real problem exists in a relocation program when it moves parts or entire towns out of the floodplain without addressing what held that community together (common link, culture, bond or sense of belonging). All of a sudden, that community quality is gone and individuals will feel displaced. People are a part of the environment and "communities need to be included if the entire ecology of the river is to be sustained. A sustainable balance with the environment is a crucial part of the planning process we have found so deficient, or missing altogether in changing and relocating communities. Holistic thinking is needed to plan communities that better recognize and enhance their connections with the environment" (Morrish, Swenson, Baltus, 1994).

Evaluation of the Public Meetings

From June 13 to June 30, 1994, 12 open house meetings were held in various locations throughout the study area (see Figure 11-1 for locations). The Public Involvement representative from the St. Paul District attended all of the June meetings with each District's assigned public involvement person. The open house format was designed to educate, answer questions, and solicit input. As interested parties entered the meeting, they were shown a videotape describing the background and reason for the study. They then had the opportunity to look at displays that included information on the objectives, study organization, study area, and related information. Four tables each had a subject expert available for questions, along with displays of work by that discipline. The public was encouraged to ask questions and make comments at these tables. Flip charts were used with an initial list of alternatives and a list of perceived needs. The public was encouraged to identify further alternatives and needs or place a mark beside the alternatives or needs that interested them.

Overall, the comments were positive to the open house meeting format because it assured more people could take the opportunity to express their views, and those people felt the meetings were educational and contributed to their understanding. Many of the open house participants provided comments at the open house or mailed their comments later. The comments received were recorded in a matrix format. The coded matrix information was prepared in a pie chart to identify the percentage of represented groups that responded to the comment sheets from the June meetings (see Figure 11-2). The majority (34.1 percent) represented Agricultural interests, while the second largest group (23.5 percent) was represented by Self-interest. The third largest group (17.4 percent) was represented by Government (separated into four groups: Regional/local, City, County, and State Government). Other interests included: Environmental, Industry, Other, Private Interest Groups, Planning, and Mental Health.

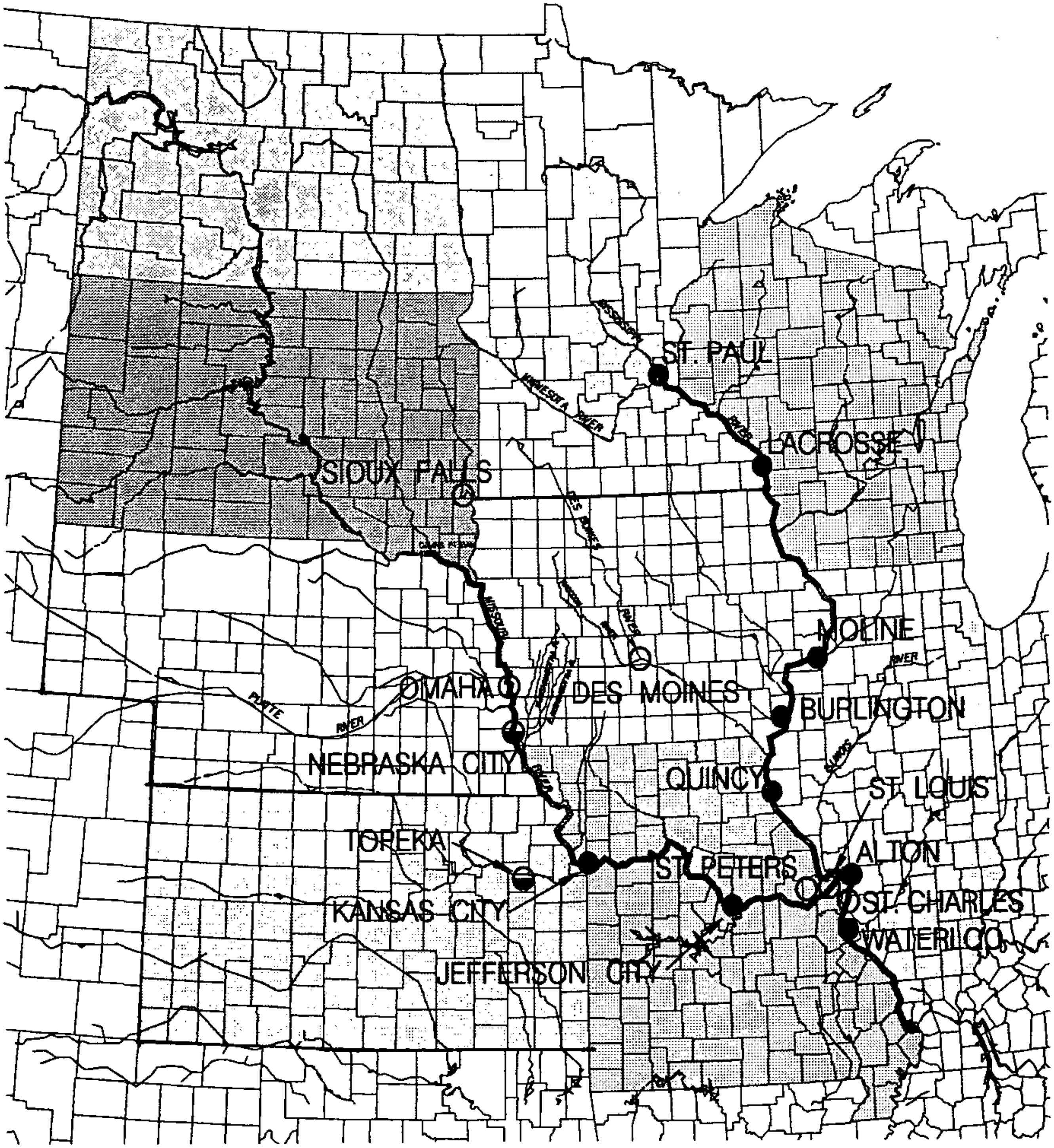
A content analysis of the comments received from the June meeting reveals **four underlying themes**. **First**, there is strong support among agricultural interests for improving and continuing development of structural flood control measures, especially levees. **Second**, the environmental interests together with some agricultural and recreational interests tend to support the idea that greater emphasis needs to be placed on nonstructural measures, particularly those that will provide environmental enhancements and benefits. **Third**, agricultural, environmental, and government representatives are asking for greater coordination among agencies responsible for managing the upper Mississippi and lower Missouri Rivers. The **Fourth** theme suggested is the genuine interest in understanding the flood of 1993. Other comments from the June 1994 meetings focused on specific problem areas, often calling for detailed solutions.

In November 1994, 13 meetings were held at locations within the study area (see Figure 11-1). These meetings followed the same basic format: a set of slides and a script were provided by the St. Paul District. The Rock Island District varied somewhat by conducting a focus meeting, before the public meetings were held, to help clarify the format and style of presentation.

Many interested parties that attended the November 1994 public meetings voiced concern about a wide variety of issues involved in the floodplain study. Some meetings were dominated by one main issue while others had a discussion on a wide variety of issues. Others provided written comments about their desires or concerns. These comments were coded and tabulated in a matrix format. Comments were grouped into nine categories as desires and concerns, shown by percentages on Figure 11-3. The three main desires expressed were: 1) **structural flood control**; 2) **watershed management**; and 3) **nonstructural flood control**. Other concerns were voiced or written and categorized into six groups: 1) **floodplain use**, storage capacity and characteristics; 2) existing **river management**; 3) value of the **study**; 4) **economics** costs and benefits; 5) **environmental** concerns; and 6) **agricultural** issues.

The following discussion provides further evaluation of the comments received. One of the limitations of this evaluation is its subjectiveness and anecdotal method of recording comments. Many of the comments mentioned about people's desires revolved around two issues. (1) The first was structural methods of flood control, especially levees: their good qualities and the value of the 500-year levee. Other recommendations were to raise heights and build more levees. On the reverse side, some people thought levees were high enough but needed better maintenance and improved interior drainage. Approximately a dozen people were in the middle: they wanted to keep levees low and reduce costs.

FLOODPLAIN MANAGEMENT ASSESSMENT



LEGEND

● 3 MEETINGS
◒ 2 MEETINGS
○ 1 MEETING

PUBLIC MEETING LOCATIONS

US Army Corps of Engineers

Figure 11-1

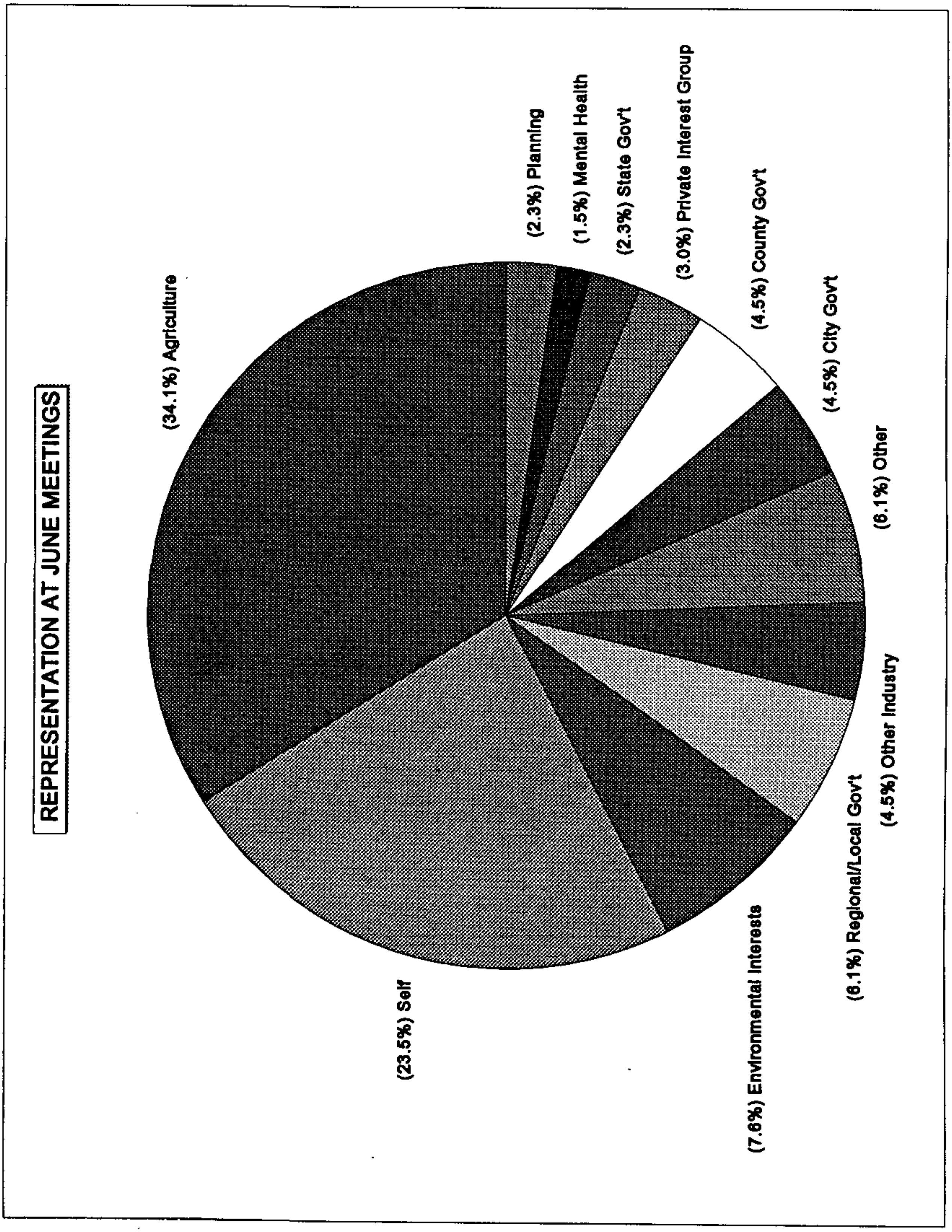

REPRESENTATION AT JUNE MEETINGS
(34.1%) Agriculture
(2.3%) Planning
(1.5%) Mental Health
(2.3%) State Gov't
(3.0%) Private Interest Group
(4.5%) County Gov't
(4.5%) City Gov't
(6.1%) Other
(4.5%) Other Industry
(6.1%) Regional/Local Gov't
(7.6%) Environmental Interests
(23.5%) Self

Figure 11-2

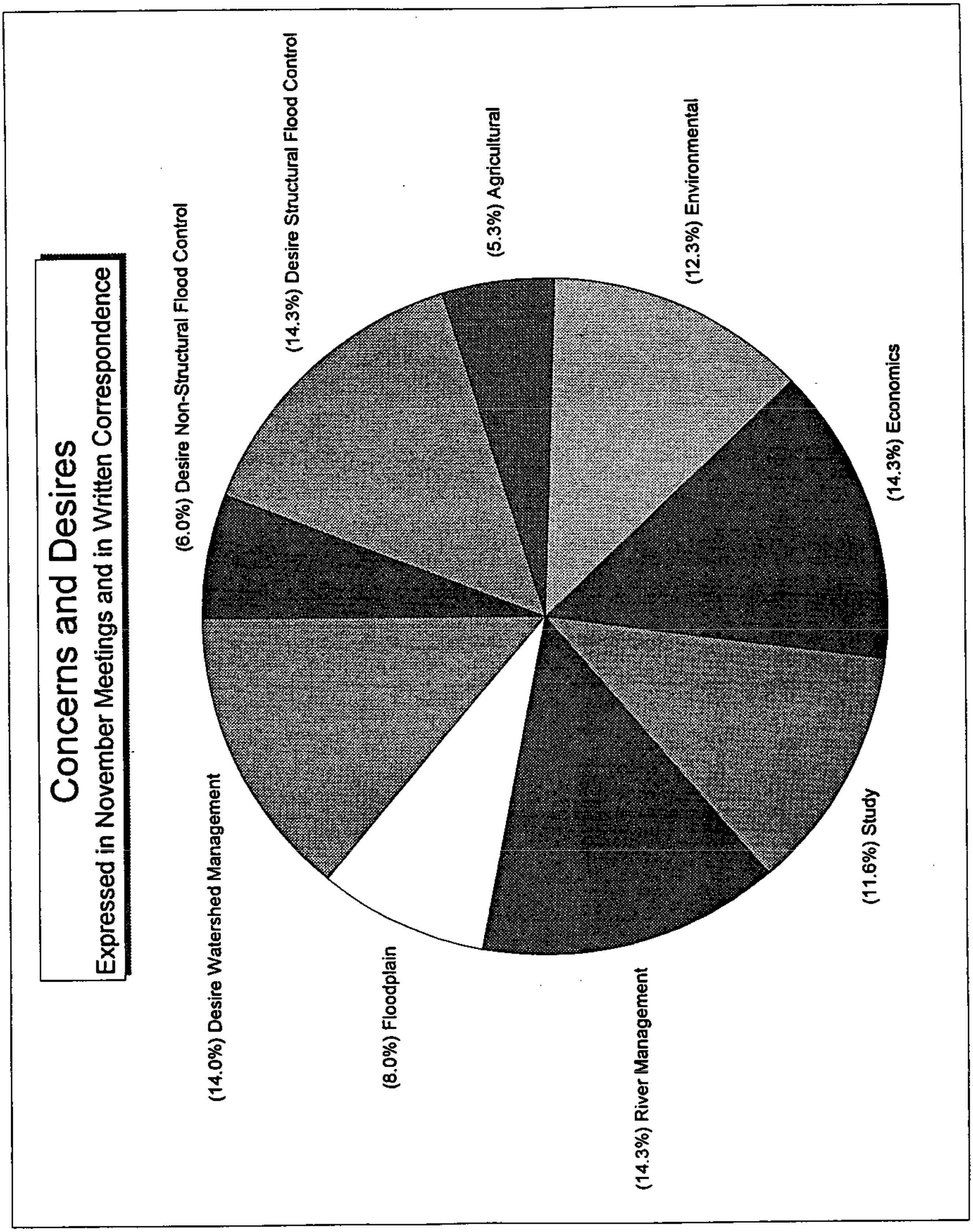

Concerns and Desires
Expressed in November Meetings and in Written Correspondence
(6.0%) Desire Non-Structural Flood Control
(14.3%) Desire Structural Flood Control
(5.3%) Agricultural
(12.3%) Environmental
(14.3%) Economics
(11.6%) Study
(14.3%) River Management
(8.0%) Floodplain
(14.0%) Desire Watershed Management

Figure 11-3

(2) The second most mentioned desire was for watershed management using optimum management plans, including tributaries, hydrologic setting, groundwater interactions, and the need for a complete analysis to take specific watersheds into account. Nonstructural flood control was mentioned less often, but many comments that relate to these desires were placed under categories such as River Management, Environmental, and Floodplain concerns. Six concerns were listed: **River Management** (14.3 percent): impacts of dredging, navigation, water levels, recreation, and the need for river-wide policies; **Environmental** (12.3 percent): concerns about ecosystems, cumulative effects, water quality, impacts to species, social well-being, historic preservation, and the value of wetlands; **Economics** (14.3 percent): concerns expressed about costs vs. benefits, measuring impacts by dollars vs. acre, housing, maintenance and improvement costs of levees, and the need for quicker financial response to flooding; **Study** (11.6 percent): was very complex and difficult to understand, needed more scenarios, lack of confidence in but was well received at some meetings, is it worth it? and what will happen when it is completed?; **Floodplain** (8.0 percent): encroachment, property value and rights, lost storage capacity, land use, hydrologic setting, and critical facility sites; and **Agricultural** (5.3 percent): value, subsidies, protection, and flooding improves land fertility. Information on how the comments were coded can be found in Appendix D.

Many of the comments from the November 1994 public meetings and the second milestone package dated September 15, 1994 were addressed in the third milestone package dated January 18, 1995 and sent to the master mailing list of approximately 200 governmental agencies/offices, interest groups and organization representatives. The third milestone package was also sent to other groups and individuals who requested the information, as a separate mailing from each District.

After the second set of meetings in November 1994, the Public Involvement Work Group discussed changes to the next round of meetings and the need to identify the priorities for the Policies/Programs and the Action Alternatives. A device was needed to allow individuals who would be attending the April 1995 public meetings to express their priorities in a uniform, but effective way. Two evaluating techniques were discussed at length: 1) the ballot procedure and 2) the comment sheet. The comment sheet was selected as the most favored technique with the use of an increment scale from 1 (low) to 5 (high) to rate individual priorities. An example of the comment sheet is in the Public Involvement Appendix D. Before the meetings were held, agencies, organizations/groups and individuals on the master and District lists received the draft report. Other individuals who later indicated a strong interest in the study were sent either the draft report or the Executive Summary with the Findings and Conclusions, depending on their request.

The third set of public meetings were held during the last two weeks of April 1995. Eleven meetings were conducted within five Districts. Handouts were available to the public at all meetings. They included: the Executive Summary, Hydraulic summary with tables of alternative actions affecting the floodplain, Findings, and Conclusions. Those in attendance were given a comment sheet to fill out before leaving the meeting. The presentation format consisted of a 30- to 40-minute slide show with a brief narrative. The slides were prepared so that each District could select from two action alternative case studies. The presentation was designed to educate the public by presenting the products from the study, existing base conditions, policy and program findings, and action alternative evaluations from the FPMA draft report. After the presentation, those in attendance were asked to complete the comment sheet, identifying their priorities on Policies/Programs and Action Alternatives, while keeping in mind that the goal of floodplain management was to (1) minimize the vulnerability of people to floods, (2) reduce flood damages and costs, and (3) assure a healthy floodplain environment.

Responses to the comment sheet questions have been recorded by computer, using a statistical package to quantify the results. The majority of the public meeting participants that chose to complete the comment sheets represented agricultural interests. Agricultural interests from Rock Island, Kansas City, St. Louis, and Omaha Districts had a combined total of 67 percent attendance, while the St. Paul District had only 5.3 percent attendance for agricultural interests, pulling the total down to 54.68 percent. Other interest groups were not as well represented: home owners = 11.68 percent, government = 12.6 percent, and environmental = 5.8 percent. Priorities were ranked by individuals who attended the April public meetings. Overwhelmingly, all Districts gave a very high (5) priority rating to: **1) protect critical facilities (56.4 percent)**; and **2) upland retention and additional watershed measures (57 percent)**. Since the attendance at most meeting sites consisted of a majority of agricultural interests, correlations by other interest groups are not necessarily representative of the attitudes of a larger population sample. Therefore, the measures of association here are limited to the agricultural interests only. Agricultural interests show an association with raising agricultural levees, but not with uniform levee heights, levee setbacks, or agricultural support policies. That interest group also shows a very low priority correlation with relocation and mitigation programs, wetland restoration programs, limited floodfighting, and removing agricultural levees. An interesting observation shows that these associations get stronger farther south (below Moline) on the Mississippi River, but are evenly distributed along the entire Missouri River in the study reach. The results of the tabulation by District follow.

St.Paul District: Two meetings were held in St.Paul, Minnesota and in LaCrosse, Wisconsin. The number of people who attended was a small but diverse group.

Attendance: total of 27
Responses received: 19
Primary interest of respondents:

Agriculture	5.3%
Commercial	10.5%
Government	26.3%
Home owner	26.3%
Environment	15.8%
Recreation	5.3%
Other	10.6%

Where respondents live:

Outside of flood plain	57.9%
Unprotected urban flood plain	26.3%
Protected urban floodplain	5.3%
Other	10.5%

The following priorities were rated by the respondents on an increment scale from 1 to 5. A very high or very low indicates that more than 50% rated the issue either 5 (Very high) or 1 (Very low). A high or low indicates that more than 50% rated the issue 4 or 2 (above or below neutral).

Priorities on program and policies:	St.Paul	LaCrosse
National flood insurance	High	--
State flood plain management	High	--
Local flood plain management	High	High
Relocation and mitigation	High	--
Disaster relief programs	--	Low
Flood plain wetland restoration	High	High
Agricultural support policies	--	Low

Priorities on alternatives:		
Limit flood fighting	--	--
Remove agricultural levees	Low	--
Agricultural levee setbacks	--	--
Uniform levee height	--	--
Raise agricultural levees	Low	Low
Raise urban levees	--	--
Protect critical facilities	High	High
Upland retention	High	Very high

A correlation between the respondents' primary interest and how the issue was ranked showed differences in opinions. Associations between interest groups and their priority ranking of 1) policies/programs and 2) alternatives are shown below:

Interest Group	Environmental	Government	Home
National Flood Insurance	High	--	Very high
State flood plain management	High	High	Very low
Local flood plain management	High	High	Low
Relocation and mitigation	High	High	Very low
Disaster relief	High	--	Very low
Floodplain wetland restoration	High	Very high	--
Agriculture support policies	Low	--	Very low
Limit flood fighting	--	High	--
Remove agriculture levees	High	--	Low
Agricultural levee setbacks	High	High	Low
Uniform levee height	--	--	Low
Raise agricultural levees	Low	Very low	Very low
Raise urban levees	--	--	Low
Protect critical facilities	Very high	Very high	--
Upland retention	Very high	Very high	--

Rock Island District: Three meetings were held in Moline and Quincy, Illinois; and Burlington, Iowa. The majority of respondents attending were representing agricultural interests. It must be cautioned that the numbers for those who indicated a primary interest other than agriculture are relatively small and the results do not necessarily reflect the attitude of a larger population.

Attendance: total of 167
Responses received: 145
Primary interest of respondents:

Agriculture	61%
Government	10%
Home owner	10%
Environment	6%
Other	13%

Where respondents live:

Protected agricultural flood plain	47%
Outside of flood plain	37%
Unprotected urban flood plain	8%
Other	8%

Priorities were rated by the respondents on an increment scale from 1 to 5. A very high or very low indicates that more than 50% rated the issue either 5 (Very high) or 1 (Very low). A high or low indicates that more than 50% rated the issue 4 or 2 (above or below neutral).

Priorities on the policy issues were fairly mixed. Only local floodplain management received a high rating with more than 50% of the respondents listing this policy as a 4 or 5. Only relocation and mitigation and floodplain wetland restoration received low ratings.

The opinions on alternatives were more clear cut. This was primarily because the issues were more understandable and could be perceived as having a more direct effect on the respondents. Levee setbacks received the only low rating while all of the others received high ratings. Clearly, raising levees, protecting critical facilities and upland retention were the preferred alternatives. Results by meeting site are shown below:

Priorities on program and policies:	Moline	Burlington	Quincy
National flood insurance	--	Low	High
State flood plain management	High	Low	High
Local flood plain management	High	--	High
Relocation and mitigation	--	Low	Low
Disaster relief programs	--	--	--
Flood plain wetland restoration	--	Low	Very Low
Agricultural support policies	--	--	High

Priorities on alternatives:			
Limit flood fighting	--	Very low	Very low
Remove agricultural levees	--	Very low	Very low
Agricultural levee setbacks	--	Very low	Low
Uniform levee height	--	Very high	High
Raise agricultural levees	--	Very high	Very high
Raise urban levees	--	High	Very high
Protect critical facilities	High	Very high	Very high
Upland retention	Very high	Very high	Very high

A correlation between the primary interest and the issue ranked also showed differences in opinions.

Interest Group:	Agriculture	Government	Home
Flood Insurance	--	--	--
State flood plain management	--	High	High
Local flood plain management	--	Very high	Very high
Relocation and mitigation	Very high	High	High
Disaster relief	--	--	High
Floodplain wetland restoration	Very low	--	--
Agriculture support policies	--	High	--
Limit flood fighting	Very low	--	--
Remove agriculture levees	Very low	--	Low
Agriculture levee setbacks	Low	--	--
Uniform levee height	High	--	High
Raise agriculture levees	Very high	--	High
Raise urban levees	Very high	--	--
Protect critical facilities	Very high	High	Very high
Upland retention	Very high	High	Very high

It must be cautioned that the numbers for those who indicated a primary interest other than agriculture are relatively small and the above results do not necessarily reflect the attitude of a larger population.

Kansas City District: Two meetings were held in Kansas City and Jefferson City, Missouri. The majority of persons attending represented agricultural interests. The district was prepared for questions on the Missouri River Master Manual by having a representative attend the meeting and discuss later.

Attendance: total of 108
Responses received: 76
Primary interest of respondents:

- Agriculture 75%
- Commercial 2.6%
- Environment 1.3%
- Government 7.9%
- Home owner 9.2%
- Recreation 2.6%
- Regional Planning 1.3%

Where respondents live:

Protected agricultural floodplain	32.9%
Unprotected agricultural floodplain	21.1%
Outside of floodplain	32.9%
Protected urban floodplain	1.3%
Unprotected urban floodplain	10.5%
Other	1.3%

Priorities were rated by the respondents on an increment scale from 1 to 5. *A very high or very low indicates that more than 50% rated the issue either 5 (Very high) or 1 (Very low).* A high or low indicates that more than 50% rated the issue 4 or 2 (above or below neutral),

Priorities on program and policies:	Kansas City	Jefferson City
National flood insurance	--	--
State flood plain management	High	--
Local flood plain management	High	High
Relocation and mitigation	--	--
Disaster relief	--	--
Flood plain wetland restoration	Very low	Very Low
Agricultural support policies	High	High

Priorities on alternatives:		
Limit flood fighting	Very low	--
Remove agricultural levees	Very low	Very low
Agricultural levee setbacks	Very low	Very low
Uniform levee height	--	--
Raise agricultural levees	High	--
Raise urban levees	High	--
Protect critical facilities	Very high	Very high
Upland retention	Very high	High

Interest Group	Agriculture	Government	Home
National Flood Insurance	--	High	--
State flood plain management	High	High	Very high
Local flood plain management	High	High	Very high
Relocation and mitigation	Low	--	--
Disaster relief	High	Low	High
Floodplain wetland restoration	Very low	--	Very Low
Agriculture support policies	Very high	High	High

Interest Group	Agriculture	Government	Home
Limit flood fighting	Very low	--	Very low
Remove agriculture levees	Very low	Very low	Very low
Agricultural levee setbacks	Very low	Low	Low
Uniform levee height	High	High	--
Raise agricultural levees	High	High	Very high
Raise urban levees	High	Very high	Very high
Protect critical facilities	Very high	Very high	Very high
Upland retention	High	--	Very high

St.Louis District: Three meetings were held in Alton and Waterloo, Illinois and in St.Peters, Missouri. The majority of persons attending represented agricultural interests.

Attendance: total of 181
Responses received: 88
Primary interest of respondents:

Agriculture	59.1%
Government	8.0%
Home owner	10.2%
Environment	3.4%
Unknown	13.6%
Other	5.7%

Where respondents live:

Protected agricultural floodplain	61.4%
Outside of floodplain	30.7%
Protected urban floodplain	5.7%
Other	2.3%

The following priorities were rated by the respondents on an increment scale from 1 to 5. A very high or very low indicates that more than 50% rated the issue either 5 (Very high) or 1 (Very low). A high or low indicates that more than 50% rated the issue 4 or 2 (above or below neutral).

Priorities on program and policies:	Alton	St.Peters	Waterloo
National flood insurance	--	--	High
State flood plain management	--	High	--
Local flood plain management	High	High	High
Relocation and mitigation	Low	--	Low
Disaster relief programs	--	--	--
Floodplain wetland restoration	Low	Very low	Very Low
Agricultural support policies	--	--	Very high
Priorities on alternatives:			
Limit flood fighting	--	Very low	Very low
Remove agricultural levees	Very low	Very low	Very low
Agricultural levee setbacks	Low	Very low	Very low
Uniform levee height	--	--	--
Raise agricultural levees	--	--	Very high
Raise urban levees	--	--	--
Protect critical facilities	Very high	Very high	Very high
Upland retention	Very high	Very high	Very high

A correlation between the primary interest and the issue ranked also showed differences in opinions.

Interest Group	Agriculture	Government	Home
National Flood Insurance	--	High	High
State flood plain management	--	Very high	High
Local flood plain management	High	Very high	High
Relocation and mitigation	Low	--	Low
Disaster relief	--	High	--
Flood plain wetlands	Very low	Low	Low
Agricultural support policies	High	Low	High
Limit flood fighting	Very low	--	Low
Remove agriculture levees	Very low	Very low	Very low
Agricultural levee setbacks	Very low	--	Very low
Uniform levee height	High	--	Very low
Raise agricultural levees	Very high	--	--
Raise urban levees	--	--	Very high
Protect critical facilities	Very high	High	Very high
Upland retention	Very high	Very high	Very high

It must be cautioned that the numbers for those who indicated a primary interest other than agriculture are relatively small and the above results do not necessarily reflect the attitude of a larger population.

Omaha District: One meeting was held at Nebraska City, Nebraska. The majority of persons attending represented agricultural interests.

Attendance: total of 60
Responses received: 37
Primary interest of respondents:

Agriculture	73.0%
Commercial	2.7%
Government	10.8%
Home owner	2.7%
Environment	2.7%
Industry	5.4%
Other	2.7%

Where respondents live:

Outside of flood plain	43.2%
Unprotected agriculture floodplain	8.1%
Protected agriculture floodplain	48.6%

The following priorities were rated by the respondents on an increment scale from 1 to 5. A very high or very low indicates that more than 50% rated the issue either 5 (Very high) or 1 (Very low). A high or low indicates that more than 50% rated the issue 4 or 2 (above or below neutral).

Priorities on program and policies:	Omaha
National flood insurance	--
State flood plain management	--
Local flood plain management	High
Relocation and mitigation	Low
Disaster relief programs	--
Flood plain wetland restoration	Very low
Agricultural support policies	Very high

Priorities on alternatives:

Limit flood fighting	Very low
Remove agricultural levees	Very low
Agricultural levee setbacks	Very low
Uniform levee height	High
Raise agricultural levees	High
Raise urban levees	High
Protect critical facilities	Very high
Upland retention	Very high

A correlation between the respondents primary interest and how the issue was ranked showed differences in opinions. Associations between interest groups and their priority ranking of 1) policies/programs and 2) alternatives is shown below:

Interest Group	Agriculture	Government	Industry
National Flood Insurance	--	Very high	--
State floodplain management	--	Very high	Very low
Local floodplain management	High	Very high	Very low
Relocation and mitigation	Very low	Very high	High
Disaster relief	--	--	High
Floodplain wetland restoration	Very low	High	Very low
Agricultural support policies	Very high	High	Very low
Limit flood fighting	Very low	High	Very low
Remove agriculture levees	Very low	Low	Very low
Agricultural levee setbacks	Very low	High	High
Uniform levee height	High	High	High
Raise agricultural levees	High	Very low	Very high
Raise urban levees	High	Very low	Very high
Protect critical facilities	Very high	Very high	Very high
Upland retention	Very high	Very high	Very high

It must be cautioned that the numbers for those who indicated a primary interest other than agriculture are relatively small and the above results do not necessarily reflect the attitude of a larger population.

Conclusion

The open house format for the June 1994 meetings contributed to the participants' understanding and provided them an opportunity to express their views. Over 78 percent of the attendance at the June meetings was represented by three interest groups: 1) agricultural interests (34 percent), 2) self-interest (24 percent), and 3) government interests (State, county, regional, local, and city) (20 percent). The November 1994 public meetings were formatted to present the study information and solicit comments. The interest groups were not tracked at this meeting. Many issues were brought out that focused on structural and nonstructural flood control, watershed management, river management, floodplain issues, environmental concerns, study concerns, economic issues, and agricultural concerns. The format for the April 1995 public meetings was changed to identify the interest groups attending and their priorities on the policies, programs and alternatives as presented in the draft FPMA report.

Interagency team workshops with local, State and Federal agencies took place during February 1994, August 1994, October 1994, January 1995, February 1995, and May 1995. Many of the written and voiced comments from the November 1994 public meetings and workshops were addressed in the third milestone package dated January 18, 1995 and sent to the master mailing list of approximately 200 governmental agencies/offices, interest groups, organizations and other interested individuals.

The majority of attendance at the public meetings represented agricultural interests. Overwhelmingly, all interest groups within the study area who chose to complete the comment sheets at the April 1995 public meetings indicated a very high (5) priority rating to **1) protect critical facilities (56.4 percent)** and to use **2) upland retention and additional watershed measures (57 percent)**. The desire for watershed management was also as strong an issue as the desire for structural flood control. Since the majority attendance at four of the five District public meeting sites consisted of agricultural interests, correlations by other interest groups are not necessarily representative of the attitudes of a larger population sample. However, there are always exceptions. Since government agencies attended team meetings and were represented at all the public meetings, with a ratio of 8 to 26 percent attendance, it is important to identify their priorities. Government interests rated a high to very high priority for local and State floodplain management and a low priority for removal of agricultural levees. Agricultural interests showed a high association with raising agricultural levees, but only south of Burlington, Iowa, on the Mississippi River and on the Missouri River. The above association does not occur above Burlington, Iowa, and north to St.Paul, Minnesota. Agricultural interests have a very low association with wetland restoration programs, limited floodfighting, agricultural levee setbacks, and removing agricultural levees. An interesting observation is that these associations are stronger farther south on the Mississippi River, but include the entire Missouri River within the study reach.

For more information on the above, see Appendix D. The coded matrix tables from each set of public meetings and the written comments from individuals, State/Federal agencies, organizations, and interest groups are also included in Appendix D - Public Involvement of the Floodplain Management Assessment Report for the Upper Mississippi and Lower Missouri Rivers. Also included in Appendix D is the inventory data collected for an Institutional Analysis.

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Findings

11-a) Comments heard and read throughout the public involvement process confirmed strong support for three main themes: 1) levees among agricultural interests, 2) nonstructural measures and upland watershed management plans by all interests, and 3) agricultural, environmental, and government representatives are asking for greater coordination among agencies responsible for managing the upper Mississippi and lower Missouri Rivers.

11-b) Overwhelmingly, the priority response throughout the region, at the April 1995 public meetings, was to 1) protect critical facilities and 2) use upland retention and additional watershed measures.

11-c) The success of any change in floodplain management will require complex coordination among all concerned interests (public agencies, private interest groups/organizations, and local communities). Throughout all the meetings and from written correspondence, interest groups were asking for the opportunity for more involvement in the assessment process. Partnering efforts to determine future management options were mentioned often.

11-d) Desire for total watershed management was as strong an issue as the desire for structural flood control.

11-e) Any relocation program needs to provide financial resources for planning to assure the cohesiveness of the affected community.

CHAPTER 12 - CONCLUSIONS

The analyses conducted for this assessment have been an attempt to quantify, to the extent possible, relative impacts of implementing a variety of alternative policies, programs, and flood damage reduction measures. In the evaluation of these alternatives, it was necessary to do hydraulic modeling for the development of relative water stages comparing the alternatives and to gather and organize available economic and environmental data. Some of the key products that are now available for use by those involved in making floodplain management decisions include the following:

a) UNET (unsteady state flow) hydraulic model from St. Paul, Minnesota, to Cairo, Illinois, on the Mississippi River and from Omaha, Nebraska, to St. Louis, Missouri, on the Missouri River;

b) Digitized land use mapping;

c) The Environmental Resource Inventory for the Upper Mississippi River, Lower Missouri River, and major tributaries;

d) Critical facility inventory and maps;

e) Watershed mapping indicating areas of greatest potential for wetland restoration;

f) Historical account of the use of the floodplain and flood control on the Mississippi and Missouri Rivers;

g) Listing and information on the many organized "stakeholders" with direct interests in future floodplain management decisions;

h) A study that compared State floodplain management programs; and

i) Expanded capability and use of electronic mail and Internet for research and data transmission.

The following are the most significant determinations resulting from the assessment. These conclusions are supported by the preceding report text and findings listed at the end of report chapters.

* Corps reservoirs performed well, reducing flood water elevations along the main stems of the Upper Mississippi and Lower Missouri Rivers by several feet in most locations. Structural flood protection (urban levees and floodwalls) performed as designed in protecting large urban centers. The Congressional General Accounting Office concluded that "most Corps levees performed as designed and prevented significant damages" (page 11 of report dated February 28, 1995). (Chapter 1)

* The total damages prevented by reservoirs and levees have been
estimated at $11 billion and $8 billion, respectively. (Chapter 1)

* Floods greater than the 1993 flood catastrophe will happen in the future. It would be prudent to prepare for future floods larger than the 1993 event. When we are properly prepared for catastrophic flood events, smaller floods will be more easily accommodated. (Chapter 1)

* The Federal philosophy of floodplain management recognizes that flood damage avoidance measures should generally be the first defense against flooding, complemented by nonstructural and structural flood protection measures where appropriate, with public education and flood insurance included as essential components to address the residual risk of flooding. (Chapter 2)

* At least 50 percent of the total 1993 flood damages were agricultural and approximately 80 percent of the 1993 crop damages region-wide were caused by overly saturated fields or other factors unrelated to overbank flooding. These losses would not have been affected by changes in floodplain management policies. The best option to address these damages is a rational program of crop damage insurance. Crop insurance reform legislation (Title I of Public Law 103-354) was enacted late in 1994. (Chapter 3)

* For the 120 counties adjacent to the Upper Mississippi and Lower Missouri Rivers and several of their major tributaries that were the focus of this assessment, urban damages substantially exceeded agricultural losses. Overbank flooding and problems associated with urban drainage and stormwater runoff continue to occur in a number of locations, as confirmed by the 1993 event. (Chapters 3 and 5)

* Expenditures for the 1993 flood through the National Flood Insurance Program and the Federal Crop Insurance Corporation were less than half of the disaster aid payments made for human resources and agricultural needs. (Chapter 3)

* A flood is the major way that exchanges of nutrients, organic matter, and organisms take place between the main channel and lateral floodplain areas. Thus, even though levees do prevent some environmental damages, they also break the linkage of floodplain ecosystem components. (Chapter 3)

* The definition of "floodplain location," using the 100-year flood outline, may not be adequate. Twenty-four percent of all losses covered by the National Flood Insurance Program for the years 1978-1993 were for damages outside (above) the 100-year floodplain. Some of these problem areas are related to high groundwater from heavy rainfall or poor interior drainage not directly related to a general condition of overbank flooding. (Chapter 7)

* State and local floodplain zoning ordinances and regulations could be most effective in determining the siting of critical facilities that have the potential for releasing toxic or hazardous elements into the environment when flooded. (Chapter 7)

* Future disaster assistance and insurance needs could be significantly reduced if the problem of repetitively damaged structures is firmly addressed through implementation of existing regulations by local, State, and Federal agencies. (Chapter 7)

* More extensive reliance on flood insurance would better assure that those who invest, build, and live in the floodplain accept appropriate responsibility for the damages and other losses that result from floods. (Chapter 7)

* More emphasis is now being placed on use of flood hazard mitigation measures, especially acquisitions of flood prone structures, as an action that will reduce repeated Federal disaster expenditures and other costs associated with areas of widespread and potentially substantial repetitive flooding. (Chapter 7)

* Conversion or restoration of a small percentage of agricultural land use to wetland or other natural conditions can significantly increase the existing percentage of natural floodplain acreage. (Chapter 7)

* Current theories on floodplain function predict that the area needed for an improvement to the natural biota is probably fairly small and that restoration of a series of natural floodplain patches (a string of beads) connected by more restricted river corridors would be practical and beneficial. (Chapter 7)

* The criteria for identifying floodplain agricultural lands that are most feasible for conversion appear to be those lands that: (Chapters 3, 7, and 9)

a) currently are being farmed that might otherwise be uneconomical, except for incentive supports, including any outside costs associated with constructing and maintaining agricultural levees (e.g., the 80 percent Federal share on Public Law 84-99 levee repairs);

b) could be restored or converted to a valuable wetland at a reasonable cost;

c) would contribute to flood damage reduction;

d) are vulnerable due to levees determined to be inappropriately located, given hydraulic conditions in the floodway; and

e) are owned by landowners who are willing to voluntarily cooperate with the restoration or conversion.

* Use of acreage reserve, acquisition, and environmental restoration programs is an effective way to remove vulnerable agricultural production from marginal lands and to generate many environmental benefits. (Chapter 7)

* Acreage reserve programs in upland areas have significant environmental benefits in the areas such as water quality, reduced sedimentation, increased wildlife habitat, and reduced peak runoff for local flood reduction benefit for frequent events, but do little to reduce stages on the main stem rivers for catastrophic events. (Chapter 7)

* From a hydraulic evaluation perspective, the FPMA analysis illustrates that no single alternative provides beneficial results throughout the system. Applying a single policy system-wide may cause undesirable consequences at some locations. Examination of many factors such as computed peak stages, discharges, flooded area extent, and depth within flooded areas is necessary to evaluate how an alternative affects performance of the flood damage reduction system as a whole. (Chapter 8)

* The importance of evaluating hydraulic impacts systemically is clear from the results of the unsteady state hydraulic modeling. Changes that affect the timing of flood peaks or the "roughness coefficients" of the floodplain can be as significant as changes in storage volume. (Chapter 8)

* If the agricultural levees along the upper and middle Mississippi River had been raised and strengthened to prevent overtopping in the 1993 event, the flood stages on the middle Mississippi River would have been an average of about 6 feet higher. Likewise, raising the levees to prevent overtopping on the Missouri River would have increased the stage by an average of 3 to 4 feet, with a maximum of 7.2 feet at Rulo, Nebraska, and 6.9 feet at Waverly, Missouri. (Chapter 8)

* Hydraulic routings assuming agricultural levees are removed show that, with continued farming in the floodplain, 1993 stages would be reduced an average of 2 to 4 feet on the Mississippi River in the St. Louis District. If this area would have returned to natural forested conditions, most of the system would still have shown reductions in stage (up to 2.8 feet), but increases in stages by up to 1.3 feet would also be seen in a few locations. In the Kansas City District, hydraulic modeling shows changes in stages of -3 feet to +1 foot for no levees with agricultural use and -3 to +4.5 feet with forested floodplains. (Chapter 8)

* Modeling results demonstrated that agricultural levee removal does not always provide uniform stage and discharge reduction. When levees are overtopped, they act as detention dams, skimming volume off the peak portion of the hydrograph. When levees are removed, the flow continues downstream in the enlarged floodway. As a result, higher flows may be experienced downstream at critical facilities and urban areas, causing increased stages at these locations. (Chapter 8)

* Converting floodplain agricultural land to natural floodplain vegetation would not reduce stages but would marginally reduce damage payments in the 1993 Midwest flood. Agricultural use of the floodplain is appropriate when the residual damage of flooding is understood and accepted within a financially sound program of crop insurance and flood damage reduction measures and when it is compatible with the risk to natural floodplain functions. (Chapters 7 and 8)

* Hydraulic modeling of reducing the runoff from the upland watersheds by 5 and 10 percent predicted average stage decreases of about 0.7 foot and 1.6 feet, respectively, on theupper and middle Mississippi River and about 0.4 and 0.9 foot, respectively, on the Lower Missouri River. However, wetland restoration measures alone would not have achieved this level of runoff reduction for the 1993 event because of the extremely wet antecedent conditions. Restoration of upland wetlands would produce localized flood reduction benefits, but would have little effect on main stem flooding caused by the 1993 event. There are other reasons for why restoration of upland wetlands is very important, such as reduced agricultural exposure to flood damage, water quality, reduced sedimentation, and increased wildlife habitat. (Chapter 8)

* Wetlands may reduce local flooding in the uplands by up to 25 percent where contributing areas are small. Restoration of such wetlands would not have affected flooding in the lower floodplain reaches for the 1993 event because most depressional areas were already full of water throughout the watershed, as normally occurs during major flood events. (Chapter 8)

* The potential to reduce flooding with further upland measures varies. In the watersheds that contributed the greatest percentage of runoff, wetlands and revised agricultural practices would have had minimal effect for the 1993 event. Major structural flood control storage reservoirs would be required to achieve the additional 10 percent volume reduction used for the analysis. (Chapter 8)

* Without a proper analysis of expected costs and benefits over time, it is impossible to determine whether a particular alternative is indicated for a particular site. (Chapter 9)

* The estimated costs are $5.6 billion for raising all agricultural levees to contain the 1993 flood in just the St. Louis District. While virtually all of the agricultural levee damage would be prevented, substantially more of the unprotected urban development in the city of St. Louis, St. Louis County, and St. Charles County would be more severely damaged. Approximately 60 miles of unprotected Mississippi River floodplain below St. Louis with many rural and suburban communities would suffer substantially increased flood damages. (Chapter 9)

* Adopting a standard 25-year level of protection for all agricultural levees prior to the 1993 flood would have resulted in an average stage reduction of about 3.5 feet on the middle/upper Mississippi River and about 2 feet on the Missouri River near its mouth. This decision would require implementation funding in the billions of dollars for structural modifications and real estate interests and would have resulted in significantly increased agricultural flood damages in 1993. (Chapter 9)

* Alternatives such as limiting floodfighting, removing agricultural levees (with land use remaining agricultural), and 25-year maximum height levees appear to have little net potential for reducing flood impacts. While flood stages would be somewhat reduced for these three alternatives, providing some minor reduction in non-agricultural impacts, total area flooded would increase dramatically. (Chapter 9)

* The ability of reservoirs to hold back very large volumes of runoff and thus substantially reduce downstream flooding was again proven by the 1993 flood event. (Chapter 9)

* The 100-year level of protection often provides a false sense of security. The Chesterfield-Monarch area, located near St. Louis, experienced $520 million damages in 1993 despite 100-year private levee protection. Also, providing a levee with only a 100-year level of protection in an urban area allows for unrestricted development within the protected area. When the 100-year flood event is exceeded, the resulting flood damages and potential for loss of life could be catastrophic. Consideration should be given to such possible consequences of exceeding the 100-year flood. (Chapter 9)

* Measures that would reduce damages during future floods that are not dependent upon any revised policies and programs include: (Chapters 7 and 9)

a) Good maintenance of both the existing Federal and non-Federal levee system; and

b) State and local interests enforcing land use policies to ensure that new floodplain development does not occur or is constructed to minimize damage potential (raising, floodproofing, etc.).

* A shift from dependence on disaster aid to flood hazard mitigation (floodproofing, elevating, or acquiring and relocating out of the floodplain) and flood insurance appears to be occurring. Examples of measures that warrant further consideration include: (Chapters 7, 9, and 10)

a) acquisition of structures that are repetitively damaged;

b) more widespread and stricter enforcement of flood insurance requirements for individuals, farmers, businesses, and communities (already well underway);

c) enforcing strict consistency in eligibility for the provision of disaster aid;

d) greatly increased emphasis on flood hazard mitigation planning and implementation;

e) assuring that communities and individuals are aware of the degree of risk involved in residing behind a levee in a floodplain, especially with less than Standard Project Flood (SPF) level of protection;

f) more effective floodplain management policies and zoning standards at the local level to prevent flood prone development;

g) an expanded boundary for flood risk zones to go beyond designation of "100-year" flood zones for flood insurance;

h) more upland watershed retention measures that will hold or slow rainfall runoff; and

i) continue structural protection when systemic analysis of impacts and life cycle costs indicate this is the best solution, but with an awareness of the risks associated with induced development.

* Comments heard and read from the public throughout the assessment followed three main themes, with varying degrees of acceptance among the interest groups: (Chapter 11)

a) Importance of agricultural levees;

b) Need for shifted emphasis to nonstructural measures and upland watershed measures; and

c) Need for greater coordination among agencies responsible for managing the upper Mississippi and lower Missouri Rivers.

* Overwhelmingly, the priority response from the whole region, at the April 1995 public meetings, was to 1) protect critical facilities and 2) use upland retention and additional watershed measures. (Chapter 11)

* Through the Floodplain Management Assessment (FPMA) analyses, the following efforts are considered to have the greatest value in further-

ing future understanding and enhancing sound floodplain management directions:

a) Inventory and spatial database of levees and other structures in the floodplain;

b) Inventory and Geographic Information System (GIS) database of critical facilities in the floodplain;

c) Additional hydraulic modeling (unsteady state) with more detailed mapping and coverage over portions of the main stem rivers not yet modeled and for the larger tributaries. (A system model, including the Mississippi, Missouri, Illinois, Ohio, and Arkansas Rivers, is scheduled to be available by the end of Fiscal Year 1996);

d) A real-time, unsteady state hydraulic model and tributary rainfall forecasting models for predicting flood crests in future flood emergencies;

e) Updated hydrology and hydraulics data, including discharge-frequency relationships and water surface profiles;

f) More extensive data and hydraulic modeling of upland watershed areas that have the greatest potential for flood damage reduction;

g) Development and experimental testing of biological response models that are linked to existing hydraulic and hydrologic models;

h) If a system-wide plan for flood damage reduction is desired, economic data must be collected, indicating the specific locations and elevations of damageable property; and

i) Maintain and update the environmental GIS database that has been developed in this effort. This database can serve as an important resource in developing floodplain management strategies for specific reaches and in developing a systemic management plan for natural resources.

ACKNOWLEDGEMENTS

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ATTACHMENT 1

Executive Summaries of Four Key Preceding Reports

1. Interagency Floodplain Management Review Committee Report (Galloway Report)

Copies can be obtained by contacting the following office:

> U.S. Government Printing Office
> Superintendent of Documents
> Mail Stop: SSOP
> Washington, D.C. 20402-9328
> (fee: $14.00)

The Executive Summary of the Committee's June 1994 report entitled "Sharing the Challenge: Floodplain Management into the 21st Century" is provided below:

The upper Mississippi and Missouri Rivers and their tributaries have played a major role in the nation's history. Their existence was critical to the growth of the Upper Midwest region of the United States and fostered the development of major cities and a transportation network linking the region to the rest of the world. The floodplains of these rivers provide some of the most productive farmland in the country. They offer diverse recreational opportunities and contain important ecological systems. While development of the region has produced significant benefits, it has not always been conducted in a wise manner. As a result, today the nation faces three major problems:

First, as the Midwest Flood of 1993 has shown, people and property remain at risk, not only in the floodplains of the upper Mississippi River Basin, but also throughout the nation. Many of those at risk do not fully understand the nature and the potential consequences of that risk; nor do they share fully in the fiscal implications of bearing that risk.

Second, only in recent years has the nation come to appreciate fully the significance of the fragile ecosystems of the upper Mississippi River Basin. Given the tremendous loss of habitat over the last two centuries, many suggest that the nation now faces severe ecological consequences.

Third, the division of responsibilities for floodplain management among federal, state, tribal and local governments needs clear definition. Currently, attention to floodplain management varies widely among and within federal, state, tribal and local governments.

The Interagency Floodplain Management Review Committee proposes a better way to manage the nation's floodplains. This report not only describes the nature and extent of the 1993 flooding and government efforts to cope with the event but also *presents a blueprint for change. This blueprint is directed at both the upper Mississippi River Basin and the nation as a whole. Its foundation is a sharing of responsibilities and accountability among all levels of government, business, and private citizens. It provides for a balance among the many competing uses of the rivers and their floodplains; it recognizes, however, that all existing activities in the floodplain simply cannot be discarded as inappropriate. Implementing this approach, the Review Committee believes, will bring about changes necessary to reduce flood vulnerability to both the infrequent major flood events and the more frequent smaller ones. Implementation also will reduce the environmental, social, and economic burdens imposed by current conditions on both public and private sectors.*

SHARING THE CHALLENGE - FEDERAL, STATE, TRIBAL AND LOCAL GOVERNMENTS, BUSINESSES, CITIZENS

Since passage of the Flood Control Act of 1936, the federal government has dominated the nation's flood damage reduction efforts and, as a result, the nation's floodplain management activity. Structural programs were deemed important and were also the principal sources of funds for any efforts to stem the rising tide of flood losses. In recent years, the federal government has begun to support nonstructural approaches. Many states, tribes, and local governments have developed and carried out floodplain management efforts that both reduced flood damages and enhanced the natural functions of floodplains. In carrying out these programs, however, they have been hampered by uncoordinated and conflicting federal programs, policies, regulations and guidelines that have hindered efficient floodplain management. Some state and local governments have not been as active in floodplain management. With the federal government assuming the dominant role and funding most ecosystem restoration, flood damage reduction, and flood recovery activities, the incentive has been limited for many state, tribal and local governments, businesses, and private citizens to share responsibility for making wise decisions concerning floodplain activity. Now is the time to:

* *Share responsibility and accountability for accomplishing floodplain management among all levels of government and with all citizens of the nation. The federal government cannot go it alone nor should it take a dominant role in the process.*

* *Establish, as goals for the future, the reduction of the vulnerability of the nation to the dangers and damages that result from floods and the concurrent and integrated preservation and enhancement of the natural resources and functions of floodplains. Such an approach seeks to avoid unwise use of the floodplain, to minimize vulnerability when floodplains must be used, and to mitigate damages when they do occur.*

* *Organize federal programs to provide the support and the tools necessary for all levels of government to carry out and participate in effective floodplain management.*

COMMITTEE FINDINGS

In conducting the review, the Committee divided its findings into two areas: the Midwest Flood of 1993, and Federal, State, Tribal, and Local Floodplain Management.

The Midwest Flood of 1993

In reviewing the Midwest Flood of 1993, the Committee found that:

* *The Midwest Flood of 1993 was a hydrometeorological event unprecedented in recent times. It was caused by excessive rainfall that occurred throughout a significant section of the upper Mississippi River Basin. The damaging impacts of this rainfall and related runoff were felt both in upland areas and in the floodplains. Pre-flood rainfall saturated the ground and swelled tributary rivers. Subsequent rains quickly filled surface areas, forcing runoff into the lower lands and creating flood conditions. The recurrence interval of the flood ranged from less than 100 years at many locations to near 500 years on segments of the Mississippi River from Keithsburg, Illinois, to above St. Louis, Missouri, and on segments of the Missouri River from Rulo, Nebraska, to above Hermann, Missouri. At 45 U.S. Geological Survey (USGS) gaging stations, the flow levels exceeded the 100-year mark. The duration of the flood added to its significance. Many areas were under water for months.*

* *Rainfall and floods like the 1993 event will continue to occur. Floods are natural repetitive phenomena. Considering the nation's short history of hydrologic record-keeping as well as the limited knowledge of long-term weather patterns, flood recurrence intervals are difficult to predict. Activities in the floodplain, even with levee protection, continue to remain at risk.*

* *The loss of wetlands and upland cover and the modification of the landscape throughout the basin over the last century and a half significantly increased runoff. Most losses occurred prior to 1930, but some are related to more recent drainage, flood damage reduction, and navigation development. Although upland watershed treatment and restoration of upland and bottomland wetlands can reduce flood stages in more frequent floods (25 years and less), it is questionable whether they would have significantly altered the 1993 conditions.*

* *Human activity throughout the basin has caused significant loss of habitat and ecosystem diversity. Flood damage reduction and navigation works and land use practices have altered bottomland habitat adversely.*

* *The costs to the nation from the flood were extensive. Thirty-eight deaths can be attributed directly to the flood, and estimates of fiscal damages range from $12 billion to $16 billion. Agriculture accounted for over half of the damages. More than 70 percent of the crop disaster assistance payments were made to counties in upland areas where ground saturation prevented planting or killed the crop. Nearly 50 percent of the approximately 100,000 homes damaged suffered losses due to*

groundwater or sewer backup as opposed to riverine flooding. Flood response and recovery operations cost the nation more than $6 billion. In addition, many costs cannot yet be quantified. Impacts on businesses in and out of the basin have not been calculated. Tax losses to governments are unknown. The impacts of the flood on the population's physical and mental well-being are just being identified and are of concern.

* *Flood damage reduction projects and floodplain management programs, where implemented, worked essentially as designed and significantly reduced the damages to population centers, agriculture, and industry. It is estimated that reservoirs and levees built by the U.S. Army Corps of Engineers (USACE) prevented more than $19 billion in potential damages. Large areas of Kansas City and St. Louis were spared the ravages of the flood, although several suburbs suffered heavy damages. Watershed projects built by the Soil Conservation Service saved an estimated additional $400 billion. Lands use controls required by the National Flood Insurance Program (NFIP) and state floodplain management programs reduced the number of structures at risk throughout the basin.*

* *Many locally constructed levees were breached and/or overtopped. Frequently, these events resulted in considerable damage to the land behind the levees through scour and deposition.*

* *Flooding during the 1993 event would have covered much of the floodplains of the main stem lower Missouri and upper Mississippi Rivers whether or not levees were there. Levees can cause problems in some critical reaches by backing water up on other levees or lowlands. Locks and dams and other navigation related structures did not raise flood heights. For more frequent floods -- less flow -- navigation dikes may cause some minor increase in flood heights.*

Federal, State, Tribal and Local Floodplain Management

The Review Committee examined the structure of current federal programs, relationships among federal, state, tribal and local governments, the performance of various programs during and after the flood, and the after action reports stemming from these activities. The Review Committee reached the following conclusions:

* *The division of responsibilities for floodplain management activities among and between federal, state, tribal, and local governments needs to be clearly defined. Within the federal system, water resources activities in general and floodplain management in particular need better coordination. State and local governments must have a fiscal stake in floodplain management; without this stake, few incentives exist for them to be fully involved in floodplain management. State governments must assist local governments in dealing with federal programs. The federal government must set the example in floodplain management activities.*

* *The National Flood Insurance Program (NFIP) needs improvement. Penetration of flood insurance into the target market -- floodplain occupants -- is very low, 20-30 percent. Communities choosing not to participate in the NFIP continue to receive substantial disaster assistance. Provision of major federal disaster assistance*

to those without insurance creates a perception with many floodplain residents that purchase of flood insurance is not a worthwhile investment. The mapping program is underfunded and needs greater accuracy and coverage. Some requirements within the program that vary from disaster to disaster need stabilization.

* *The principal federal water resources planning document, <u>Principles and Guidelines</u>, is outdated and does not reflect a balance among the economic, social, and environmental goals of the nation. The lack of balance is exacerbated by a present inability to quantify, in monetary terms, some environmental and social impacts. As a result, these impacts are frequently understated or omitted. Many critics of <u>Principles and Guidelines</u> see is as biased against nonstructural approaches.*

* *Existing federal programs designed to protect and enhance the floodplain and watershed environment are not as effective as they should be. They lack support, flexibility and funding, and are not well coordinated. As a result, progress in habitat improvement is slow.*

* *Federal pre-disaster, response, recovery and mitigation programs need streamlining but are making marked progress. The nation clearly recognized the aggressive and caring response of the government to the needs of flood victims, but coordination problems that developed need to be addressed. Buyouts of floodprone homes and damaged lands made considerable inroads in reducing future flood losses.*

* *The nation needs a coordinated strategy for effective management of the water resources of the upper Mississippi River Basin. Responsibility for integrated navigation, flood damage reduction and ecosystem management is divided among several federal programs.*

* *The current flood damage reduction system in the upper Mississippi River Basin represents a loose aggregation of federal, local, and individual levees and reservoirs. This aggregation does not ensure the desired reduction in the vulnerability of floodplain activities to damages. Many levees are poorly sited and will fail again in the future. Without change in current federal programs, some of these levees will remain eligible for post-disaster support. Levee restoration programs need greater flexibility to provide for concurrent environmental restoration.*

* *The nation is not using science and technology to full advantage in gathering and disseminating critical water resources management information. Opportunities exist to provide information needed to better plan the use of the floodplain and to operate during crisis conditions.*

COMMITTEE RECOMMENDATIONS

The Review Committee developed recommendations in consonance with the proposed goals:

* *To ensure that the floodplain management effort is organized for success, the President should:*

Propose enactment of a Floodplain Management Act which establishes a national model for floodplain management, clearly delineates federal, state, tribal, and local responsibilities, provides fiscal support for state and local floodplain management activities, and recognizes states as the nation's principal floodplain managers;

Issue a revised Executive Order clearly defining the responsibility of federal agencies to exercise sound judgment in floodplain activities; and

Activate the Water Resources Council to coordinate federal and federal-state-tribal activities in water resources; as appropriate, reestablish basin commissions to provide a forum for federal-state-tribal coordination on regional issues.

* *To focus attention on comprehensive evaluation of all federal water project and program effects, the President should immediately establish environmental quality and national economic development as co-equal objectives of planning conducted under the Principles and Guidelines. Principles and Guidelines should be revised to accommodate the new objectives and to ensure full consideration of nonstructural alternatives.*

* *To enhance coordination of project development, to address multiple objective planning, and to increase customer service, the Administration should support collaborative efforts among federal agencies and across state, tribal, and local governments.*

* *To ensure continuing state, tribal and local interest in floodplain management success, the Administration should provide for federal, state, tribal, and/or local cost-sharing in pre-disaster, recovery, response, and mitigation activities.*

* *To provide for coordination of the multiple federal programs dealing with watershed management, the Administration should establish an Interagency Task Force to develop a coordination strategy to guide these actions.*

* *To take full advantage of existing federal programs which enhance the floodplain environment and provide for natural storage in bottomlands and uplands, the Administration should:*

Seek legislative authority to increase post-disaster flexibility in the execution of the land acquisition programs;

Increase environmental attention in federal operation and maintenance and disaster recovery activities;

Better coordinate the environmentally-related land interest acquisition activities of the federal government; and

Fund, through existing authorities, programmatic acquisition of needed lands from willing sellers.

* *To enhance the efficiency and effectiveness of the National Flood Insurance Program, the Administration should:*

Take vigorous steps to improve the marketing of flood insurance, enforce lender compliance rules, and seek state support of insurance marketing;

Reduce the amount of post-disaster support to those who were eligible to buy insurance but did not to that level needed to provide for immediate health, safety, and welfare; provide a safety net for low income flood victims who were unable to afford flood insurance;

Reduce repetitive loss outlays by adding a surcharge to flood insurance policies following each claim under a policy, providing for mitigation insurance riders, and supporting other mitigation activities;

Require those who are behind levees that provide protection against less than the standard project flood discharge to purchase actuarially based insurance;

Increase the waiting period for activation of flood insurance policies from 5 to 15 days to avoid purchases when flooding is imminent;

Leverage technology to improve the timeliness, coverage, and accuracy of flood insurance maps; support map development by levies on the policy base and from appropriated funds because the general taxpayer benefits from this program; and

Provide for the purchase of mitigation insurance to cover the cost of elevating, demolishing, or relocating substantially damaged buildings.

* *To reduce the vulnerability to flood damages of those in the floodplain, the Administration should:*

Give full consideration to all possible alternatives for vulnerability reduction, including permanent evacuation of floodprone areas, flood warning, floodproofing of structures remaining in the floodplain, creation of additional natural and artificial storage, and adequately sized and maintained levees and other structures;

Adopt flood damage reduction guidelines based on a revised <u>Principles and Guidelines</u> which would give full weight to social, economic, and environmental values and assure that all vulnerability reduction alternatives are given equal consideration; and

Where appropriate, reduce the vulnerability of population centers and critical infrastructure to the standard project flood discharge through use of floodplain management activities and programs.

** To ensure that existing federally constructed water resources projects continue to meet their intended purposes and are reflective of current national social and environmental goals, the Administration should require periodic review of completed projects.*

** To provide for efficiency in operations and for consistency of standards, the Administration should assign principal responsibility for repair, rehabilitation, and construction of levees under federal programs to the U.S. Army Corps of Engineers.*

** To ensure the integrity of levees and the environmental and hydraulic efficiencies of the floodplain, states and tribes should ensure proper siting, construction, and maintenance of non-federal levees.*

** To capitalize on the successes in federal, state, tribal, and local pre-disaster, response, recovery, and mitigation efforts during and following the 1993 flood and to streamline future efforts, the Administration should:*

> *Through the NFIP Community Rating System, encourage states and communities to develop and implement floodplain management and hazard mitigation plans;*
>
> *Provide funding for programmatic buyouts of structures at risk in the floodplain;*
>
> *Provide states the option of receiving Section 404 Hazard Mitigation Grants as block grants;*
>
> *Assign the Director of the Federal Emergency Management Agency responsibility for integrating federal disaster response and recovery operations; and*
>
> *Encourage federal agencies to use non-disaster funding to support hazard mitigation activities on a routine basis.*

** To provide integrated hydrologic, hydraulic, and ecosystems management of the upper Mississippi River basin, the Administration should:*

> *Establish upper Mississippi River Basin and Missouri River Basin commissions to deal with basin-level program coordination;*
>
> *Assign responsibility, in consultation with the Congress, to the Mississippi River Commission (MRC), for integrated management of flood damage reduction, ecosystem management, and navigation on the upper Mississippi River and tributaries; expand MRC membership to include representation from the Department of the Interior; assign MRC responsibility for development of a plan to provide long-term control and maintenance of sound federally built and federally supported levees along the main stems of the Mississippi and*

Missouri Rivers; this support would be contingent on meeting appropriate engineering, environmental, and social standards.

Seek authorization from the Congress to establish an Upper Mississippi River and Tributaries project for management of the federal damage reduction and navigation activities in the upper Mississippi River Basin;

Establish the upper Mississippi River Basin as an additional national cross-agency Ecosystem Management Demonstration Project; and

Charge the Department of the Interior with conducting an ecosystems needs analysis of the upper Mississippi River Basin.

* *To provide timely gathering and dissemination of the critical water resources information needed for floodplain management and disaster operations, the Administration should:*

Establish an information clearinghouse at USGS to provide federal agencies and state and local activities the information already gathered by the federal government during and following the 1993 flood and to build on the pioneering nature of this effort; and

Exploit science and technology to support monitoring, analysis, modeling, and the development of decision support systems and geographic information for floodplain activities.

2. Preliminary Report of the Scientific Assessment and Strategy Team (SAST)

Copies can be obtained by contacting the following office:

U.S. Government Printing Office
Superintendent of Documents
Mail Stop: SSOP
Washington, D.C. 20402-9328
(fee: $14.00±)

A summary from the SAST report is provided below:

The SAST built a vast multilayer, multiresolution database covering the Upper Mississippi River Basin. The data densities vary spatially depending on the intensity of study that is required of the SAST. The most concentrated and complete data are along the floodplains of the upper Mississippi and lower Missouri Rivers because these floodplains represent the areas of most immediate interest to policy makers dealing with questions about response to the 1993 flood, the Federal levee system, and habitat restoration. The data are most sparse on the Upper Missouri River Basin upstream of Gavins Point, South Dakota. The primary purpose of the Upper Missouri River Basin data sets is to form a baseline of data and information for future studies *since that area did not contribute appreciably to the flood of 1993. Intermediate data densities are in the areas that contributed to the 1993 floods. The database contains advanced very high resolution radiometer (AVHRR), Landsat Thematic Mapper (TM), and other satellite data; elevation data; selected digitized photographs; historical channel geometries; artificial structures; geologic, biologic, hydrologic, hydrographic, hazardous/toxic, and soil survey data; and data on many other topics.*

Some of the SAST products include special maps, demonstrations of data applications, decision rules for identifying high priority habitat sites, methods for identifying reasonable alternative levee locations, and new understanding of the influence of variables such as focused flood-flow energy, the relationship between historical and current channel and sedimentation and scour, and land use on the impact of floods on the lower Missouri and upper Mississippi River floodplains. The use of these products for management and decision-making will be the subject of future scientific and management activities.

Data to populate the database and information for the preliminary report came from many sources including Federal agencies, state governments, universities, and nongovernment organizations (private industry and interest groups). Most data sets were modified from existing available data to make them intercomparable, to format them uniformly, or to otherwise improve their quality. Due to time limitations, many problems encountered in the data were identified in the metadata and not corrected when entered into the database. Quality assurance is an ongoing effort. Many data sets that were in the form of maps and tabular listings were digitized and included if they were useful for answering questions raised in the decision-making process. Some data sets were built completely from scratch because of the critical need for them and their lack of availability.

3. <u>1993 Post-Flood Report - Corps of Engineers</u>

Copies can be obtained by contacting the following offices:

Rock Island District, Corps of Engineers
P.O. Box 2004
Rock Island, IL 61204-2004
or
Omaha District, Corps of Engineers
215 North 17th Street
Omaha, NE 68102-4978

The report includes a main report and 5 separately bound appendices for each of the 5 Corps of Engineers Districts, as follows:

- Appendix A - St. Paul District Report
- Appendix B - Rock Island District Report
- Appendix C - St. Louis District Report
- Appendix D - Omaha District Report
- Appendix E - Kansas City District Report

The Summary and Conclusions of the report are provided below:

SUMMARY AND CONCLUSIONS

Summary

The flood of 1993 was an unusual and significant hydrometeorological event that devastated the Midwest. The flooding of the Mississippi and Missouri Rivers resulted in the death of 47 people and caused between $15 and $20 billion in damage. The 1993 flood was distinctive from all other record floods in terms of its magnitude, severity, the resulting damage, and the season in which it occurred.

Excessive precipitation during April through July 1993 produced severe or record flooding in a nine-state area in the upper Mississippi River basin. Excessive precipitation also affected the Missouri River basin, adding to the flood's areal extent in three states. The rainstorms that caused the Flood of 1993 were unique both in the size of the flooded area and in the fact that the storms resulted in the Mississippi and Missouri Rivers cresting within the same week. As a result of severely high water along the Mississippi River below Dubuque, Iowa, barge traffic was suspended from late June until mid-August 1993.

Although, typically, floods occur in the spring, this flood occurred throughout the summer along the Mississippi and Missouri Rivers. Flooding and water levels above the flood stage continued through the middle of September and many regions along the Mississippi River remained above flood stage for more than 6 months.

Corps reservoirs along the upper Missouri River were able to store much of the excess runoff in Montana and North and South Dakota. However, on the Missouri River, downstream of Omaha, Nebraska, the reservoirs could not accommodate the record runoff. Portions of the Missouri River were above flood stage for several months. On the Mississippi River, there are only three reservoirs with significant storage capacity above St. Louis, Missouri. These three reservoirs are located in Iowa and are operated by the Rock Island District for flood-reduction purposes. The Corps reservoirs were able to reduce the Mississippi River stage downstream of Keokuk, Iowa. Because of the prolonged runoff periods, the maximum crest reductions from the operation of Coralville, Saylorville, and Red Rock Reservoirs amounted to 11 inches at Quincy, Illinois, and Hannibal, Missouri.

Even with these three reservoirs, the Flood of 1993 was in excess of a 100-year flood and, in some areas, perhaps even a 500-year flood. However, the people affected by this tremendous flood found little comfort in knowing that this was a rare occurrence.

As the local, state, and federal agencies prepared to provide cleanup and other assistance, additional rains in late August and September prolonged the soggy, wet conditions and caused further delays. After most floodwaters had receded, heavy rainfall in mid-November resulted in a third disaster declaration on December 1, 1993, for southeastern Missouri.

The Corps provided, on a priority basis, the emergency repairs of many federal and non-federal levees. The urgency concerned the need to try to provide *closures to breached levees and rehabilitate pumping facilities to protect against eventual spring 1994 floods. The weather was cooperative in that a freeze-up did not occur until after the time it normally occurs in mid-December.*

The weather also cooperated by producing few spring 1994 floods of only small magnitude. This has allowed for many additional repairs to take place. Some relocations of portions of towns - such as Valmeyer, Illinois, and Chelsea, Iowa - are now taking place or getting underway.

The Corps of Engineers had no authority to fund flood-damage collection efforts for this Post-Flood Report. Therefore, no new flood-damage estimates were obtained. This report and its five appendices present some damage estimates developed by local, county, and state agencies. Recently released reports by the Federal Emergency Management Agency (FEMA) provide information concerning dollars paid out for assistance under its various authorities. These reports provide data for Kansas, Illinois, Minnesota, Missouri, Nebraska, and Wisconsin. The actual flood-damage information is expected to be provided in the Corps Floodplain Assessment study, which is underway at this time. The report is to be released during the summer of 1995.

There are many accounts of the efforts of volunteers and the flood victims who helped during the flood and immediately afterward to try to restore their lives in the affected areas. Some of these accounts are documented in news articles in many of the local newspapers.

There are a number of publications and technical papers already written to date that document and further analyze the Flood of 1993. One of the most comprehensive reports to date was prepared by the Interagency Flood Plain Management River Committee, directed by Brigadier General Gerald E. Galloway. Their report, entitled "Sharing the Challenge: Floodplain Management into the 21st Century," was published on June 30, 1994. The committee had been appointed by the Administration's Floodplain Management Task Force. The report provides the committee's findings and recommendations for action.

The report represents the views of the review committee and is based on research and interactions with the federal, state, and local officers, businesses, interest groups, and individuals in and outside the upper Mississippi River basin. This 6-month effort is now in the hands of the Administration.

In addition, a number of Interagency Hazard Mitigation Team reports were prepared due to the federal disaster declarations resulting from the Flood of 1993, as required by FEMA. These reports provide actions that will reduce the potential for future flood loss. Hazard-mitigation measures are actions that individuals, organizations, and governments can take to reduce the effects of future disasters.

Another report, the National Oceanic and Atmospheric Administration's National Disaster Survey Report - The Great Flood of 1993, describes the Flood of 1993 as an unprecedented hydrometeorological event since the United States started to provide weather services in the mid-1800s.

The media brought this disastrous event into the living rooms of all U.S. citizens and provided it to the world almost on a daily basis throughout the entire flood event. No other natural disaster in U.S. history affected or touched so many lives for so long a duration as the Midwest Flood of 1993.

Conclusions

The Flood of 1993 was the worst flood event experienced by the Midwest. From the standpoint of monetary loss, it was the worst ever in the United States because of its areal extent and long duration. Details of the damage caused by the flood have been identified. Effective mitigation measures now need to be implemented in order to reduce future loss of life and property.

Flooding from this event caused major highways, bridges, and rail lines to be closed for a long period of time. Officials from these entities now will be redesigning their facilities to protect against future floods of this magnitude. Navigation was shut down on the Mississippi River (see Table 6), closing a main transportation artery to the Midwest. In the aftermath, major efforts were carried out to restore the lock operations on the Mississippi River. Many wastewater and water-supply facilities were disrupted or even totally shut down. Officials of these facilities are redesigning them to provide greater flood protection. Cost-effective measures for hazard mitigation are expected to be incorporated into the repair cost of damaged public facilities.

Damage to communities was extensive. Many are reassessing their situation and seeking relocation opportunities. Officials and owners are still evaluating the relocation of residential structures that were heavily damaged.

Major public power utilities sustained damage to electrical transmission and distribution systems. Many of these damaged utilities will need to be relocated.

Finally, the damage to farmland and pastures was severe. Some acreage may not be restored for agricultural purposes.

The federal floodplain management policy is being reassessed. Possibilities for returning some of the floodplains to their natural state - particularly to wetlands - will be studied as part of the Corps "Floodplain Management Assessment of the Upper Mississippi and Lower Missouri Rivers and Their Tributaries" report. The impacts of the Flood of 1993 are, therefore, expected to provide a planned approach to drastically reduce the flood damage of future large flood events.

4. 1993 Economic Damage Data Collection Report - Corps of Engineers

Copies can be obtained by contacting the following office:

Commander, U.S. Army Engineer Division
Lower Mississippi Valley Division
ATTN: CELMV-PE-E
P.O. Box 80
Vicksburg, Mississippi 39181-0080

The division office can be contacted for instructions on accessing the data base through INTERNET. The hard copy versions of the report have not been distributed at this time.

ATTACHMENT 2

AUTHORIZATION DOCUMENTS

Congressional acts authorizing this Floodplain Management Assessment, and the guidance memorandum from Headquarters, U.S. Army Corps of Engineers, for the conduct of the assessment are included in this attachment.

FY 1994 Energy and Water Development Appropriations Conference Report

H.R. 2445
(Signed by President October 28, 1993)

The conference agreement includes $2,000,000 for the Corps of Engineers to conduct studies of the reaches of the upper Mississippi and lower Missouri Rivers and their tributaries that were flooded in 1993. From within those funds, the conferees direct the Secretary of the Army to initiate preliminary activities on a study to assess the adequacy of current flood control measures on the upper Mississippi River and its tributaries. The study should focus on identifying public facilities, industrial, petrochemical, hazardous waste and other facilities which require additional flood protection, assess the adequacy of current flood control measures, examine the differences in Federal cost-sharing for construction and maintenance of flood control projects on the upper and lower Mississippi River system, evaluate the cost-effectiveness of alternative flood control projects, and recommend improvements to the current flood control system.

U.S. House of Representatives
COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION

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COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

R E S O L U T I O N

Upper Mississippi and Lower Missouri Rivers
and their tributaries
Docket 2423

Resolved by the Committee on Public Works and Transportation of the United States House of Representatives, That, the Secretary of the Army, acting through the Chief of Engineers, shall review the report of the Chief of Engineers on the Mississippi River between Coon Rapids Dam, Minnesota, and the mouth of the Ohio River, published as House Document 107, Eighty-first Congress, First Session; House Document 281, Eighty-third Congress, Second Session; House Document 247, Eight-third Congress, Second Session; and the reports on the Missouri River and Tributaries, published as House Document 238, Seventy-third Congress, Second Session; House Document 475, Seventy-eighth Congress, Second Session, and other pertinent reports, to determine whether modifications of the recommendations contained therein are advisable at the present time, in the interest of flood control and related purposes. The Secretary of the Army shall conduct comprehensive, system-wide studies to evaluate the flood control and flood plain management needs of the upper Mississippi and lower Missouri River and their tributaries that were flooded in 1993.

Adopted: November 3, 1993

ATTEST: [signature]
NORMAN Y. MINETA, Chair

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CECW-PC

14 DEC 1993

MEMORANDUM FOR Commander, North Central Division

SUBJECT: Flood Plain Management Assessment of the Upper Mississippi and Lower Missouri Rivers and their Tributaries

1. Enclosed is a copy of a resolution of the Committee on Public Works and Transportation, United States House of Representatives, subject: Upper Mississippi and Lower Missouri Rivers and their Tributaries, Docket 2423, dated November 3, 1993 (enclosure 1). In accordance with the following special instructions, you are assigned the task of conducting the subject flood plain management assessment, serving as the lead to facilitate overall coordination and completion of the study in a period not to exceed 18 months.

2. Funds are provided in the FY 94 Appropriations Act (enclosure 2, copy of Conference Report language) to initiate a flood plain management assessment which addresses those reaches of the Upper Mississippi and Lower Missouri Rivers and their tributaries that were flooded in 1993. The name and number of this study has been designated as "Upper Mississippi and Lower Missouri Rivers and their Tributaries - 13245". This title will be used in all future correspondence concerning this assessment.

3. If you believe there are compelling reasons for combining this resolution with any currently outstanding study resolution, please notify me as soon as possible. In addition, please provide a fact sheet utilizing the instruction in paragraph A-2.5a and the format in illustration A-2.1 in Engineer Circular (EC) 11-2-161, the FY 95 Program and Budget EC, dated 31 March 1993.

4. The time and funding resources available for this effort require that it be accomplished on a broad and conceptual basis, using a system approach to floodplain management (of which, flood control is only one aspect thereof). In conducting the study, the formulation, evaluation and ranking of potential system outputs should be viewed from the standpoint of what each particular element (e.g., sub-basin) could contribute to or have an effect on the overall system. We will provide you with additional information that further defines the context as it becomes available. In particular, White House efforts concerning long-term options have been initiated and the mission statements will be provided to your office as soon as they become available.

5. The study should be conducted within a systems context to achieve the following general objectives:

a. describe the existing land and water resources in the subject basins above the confluence of the Ohio River and make projections for future conditions;

b. identify and array the desires of interested parties within the study area to appropriately reflect the diversity and concern for future outputs from uses of flood plain resources;

c. describe how the array of land and water resources could be used to provide potential outputs from uses of flood plain resources (e.g., land use patterns (agriculture, open space, rural, urban), environmental outputs (acres of river, wetlands, marsh, prairie, woodlands), etc.);

d. describe the forces (physical, social, political, regional, national, etc.) impacting on the use of identified alternative land and water resources (e.g., array in matrix form overlapping, competing, and conflicting directions);

e. develop a broad array of alternative land and water resource actions with the potential to vary the mix of outputs;

f. evaluate and prioritize alternative land and water resource actions based on consultation and coordination with affected Federal, state and local entities through a series of public workshops or similar mechanisms; and

g. prepare a report documenting the assessment efforts and provide recommendations for subsequent detailed studies.

6. We recognize that manpower is limited in the affected districts and urge you to take advantage of staff from other districts that may have available expertise.

7. My staff is available to provide assistance upon request. Within 30 days of receipt of this memorandum, a proposed plan of implementation should be prepared and an initial In-Progress Review (IPR) meeting held to discuss how the subject study should be conducted. Additionally, the proposed implementation

CECW-PC
SUBJECT: Flood Plain Management Assessment of the Upper Mississippi and Lower Missouri Rivers and their Tributaries

plan should reflect the scheduling of appropriate follow-on IPR's to ensure that we are all in agreement with the direction in which the assessment is proceeding.

2 Encls

STANLEY G. GENEGA
Major General, USA
Director of Civil Works

ATTACHMENT 3

Endnotes for Chapter 2 Historical Evaluation

1. This historical overview can be divided into three segments defined by era, subject matter and the extent of research. The first section is a history of who the principal actors were in shaping the middle and upper Mississippi River and how those actors came to have a stake in managing the river by 1940. This section is based upon years of research and writing on these issues by the author, St. Paul District historian, Dr. John Anfinson. The second section examines the evolution of the flood protection infrastructure on the middle and upper Mississippi River and its tributaries. About 2 months of research went into this section. The research entailed compiling a table of all the projects authorized and constructed in the subject area. It also required examining, in a cursory manner, the history of floodplain management. For this reason, there is much less background on why Congress authorized the various flood control projects, and the history of floodplain management needs much more analysis. The final section is the history of the Missouri River. Historian Dr. Jane Carroll of the St. Paul District had about 2 weeks to put this section together. She relied largely on the Kansas City and Omaha District histories. This section also deserves much more research.

2. Frederick J. Dobney, *River Engineers of the Middle Mississippi: A History of the St. Louis District, U.S. Army Corps of Engineers*, (Washington, D.C.: U.S. Government Printing Office, 1978), chap. 2. Dobney shows that the Engineers carried out much more snagging and clearing on the middle Mississippi River between 1824 and 1860, but they did so in fits and starts, due to inconsistent funding from Congress. Louis C. Hunter, *Steamboats on Western Rivers: An Economic and Technological History*, (Harvard University Press, 1949; reprint New York: Octagon Books, 1969), chap. 2.

3. Dobney, *River Engineers*, pp. 52, 67-68.

4. *Laws of the United States Relating to the Improvement of Rivers and Harbors*, v. 1, House of Representatives, H. Doc. No. 1491, 62d Cong., 3d sess., (Washington: Government Printing Office, 1913), Chap. 138, p. 156; Roald Tweet, *A History of Rock Island District*, (Washington: U.S. Government Printing Office, 1984), pp. 66-67; Dobney, *River Engineers*, pp. 44-45.

5. U.S. Congress, Senate, *Report of the Select Committee on Transportation Routes to the Seaboard*, 43d Cong., 1st sess., 1874, S. Rep. 307, pt. 1, 7-8, 188, 198-99, 211, 213, 243; Dobney, *River Engineers*, p. 50.

6. Dobney, *River Engineers*, pp. 52-53.

7. U.S. Congress, House. "Mississippi River between Missouri River and St. Paul, Minn." 59th Cong., 2nd sess., H. Doc. 341, p. 3.

8. Dobney, *River Engineers*, p. 75.

9. Navigation Charts, Mississippi River, Ohio River to Minneapolis, Minn., prepared by U.S. Engineer Office, St. Louis, Missouri, September 1933.

10. *U.S. Congress, House*, "Mississippi River From Cape Girardeau, Mo., to Rock Island, Illinois," Mississippi River Commission, 63rd Cong., 2nd sess., H. Doc. No. 628, pp. 6-7; Charles W. Durham, "Reclamation and Conservation of the Alluvial Lands in the Upper Mississippi Valley, Now and Formerly Subject to Overflow," *Engineering and Contracting* 37 (January 3, 1912):21-24.

11. "Mississippi River From Cape Girardeau, to Rock Island, Illinois," H. Doc. No. 628, pp. 6-7. The Mississippi River Commission had some flood control responsibilities on the lower Mississippi River since Congress established it in 1879.

12. From 1879 to 1885, 9 levee districts organized in Illinois, claiming over 240,000 acres. This represents almost one-third of Illinois levee districts formed and over half of the acreage that would be reclaimed along the Mississippi River in that State. Nani G. Bhowmik, et al., *The 1993 Flood on the Mississippi River in Illinois*, (Champaign: Illinois State Water Survey, Miscellaneous Publication, 1994), p. 151.

13. Roald Tweet, *Rock Island District*, (Washington: U.S. Government Printing Office, 1984), p. 291. The discussion as to why Congress did not authorize any more flood control for the work until 1917 deserves much more research. My reasons are largely based on conjecture.

14. *Laws of the United States*, v. 1, pp. 419, 460, 511, 577, 637, 783; U.S. Army, Corps of Engineers, *Annual Reports of the Chief of Engineers*, 1898 (Washington, D.C.: Government Printing Office, 1866-1994), p. 1747. A former by-channel of the Mississippi River had gone around Sny Island. The levee is located between miles 261 and 315. *Water Resources Development in Illinois 1991*, (Chicago: U.S. Army Corps of Engineers, Chicago District, 1991), p. 48, hereafter all references to the Water Resources Development books will be abbreviated *WRD* after the first reference.

15. River and Harbor Act of 1894, *Laws of the United States*, v. 1, p. 704. The 1896 Rivers and Harbors Act authorized several other levee surveys to improve navigation on the upper river, but Congress did not authorize work on these. See *Laws of the United States*, v. 1, River and Harbor Act 1896, pp. 783-84.

16. *Annual Report* 1896, p. 1776; *Annual Report* 1898, p. 174.

17. To further interior drainage of the 45,000 acres protected by the Flint Creek Levee, the Engineers included 11 drainage pipes. River and Harbor Act of 1895, *Laws of the United States*, v. 1, p. 732; Tweet, *Rock Island District*, pp. 291-92; *Annual Report* 1902, pp. 1637-46; *Annual Report* 1915, p. 1881. The Warsaw to Quincy reach included the Hunt, Lima Lake and Indian Grave drainage districts, which were among the upper river's oldest and largest levee districts.

18. Todd Shallot, in a new work entitled *Structures in the Stream, Water, Science, and the Rise of the U.S. Army Corps of Engineers*, (Austin: University of Texas, 1994) challenges this assumption. He argues that the monolithic perception that Congress and the presidents before the Civil War opposed internal improvements or prevented any significant efforts in this regard is wrong. He shows that there were two strong periods of Federal involvement in internal improvements. The first began in 1824 and lasted until 1838. He calls this the era of surveys, when the Government sponsored surveys of many of the country's rivers, harbors and coasts. The second, more short lived, was from 1850 to

1853. But Shallot does not dispel the overall argument that the Federal Government did not support a large, sustained program of internal improvements. See Shallot, Chapters 4 and 5.

19. In an 1898 report for the Rock Island District, Captain C. McDonald Townsend complained that "the two methods of improvement are incompatible." To Townsend, the uncoordinated building of levees threatened the Corps' channel improvement works and, he predicted, would "only lead to disaster." He recommended preparing a comprehensive plan to integrate levee construction and channel constriction, if Congress planned to authorize more levee work. *Annual Report* 1898, pp. 1748-49.

20. "Mississippi River From Cape Girardeau, Mo., to Rock Island, Illinois," H. Doc. No. 628, pp. 6-7.

21. Dobney, *River Engineers*, pp. 78-79. River and Harbor Act of 1913, *Laws of the United States*, v. 1, p. 1597.

22. Durham, "Reclamation and Conservation," p. 21.

23. Durham, "Reclamation and Conservation," p. 21.

24. For a general history of the conservation movement, see Samuel Hays, *Conservation and the Gospel of Efficiency*, (Cambridge, 1959); Carolyn Merchant, ed., *Major Problems in Environmental History*, (Lexington, Massachusetts, 1993), Chaps. 9-11.

25. Further study would help identify who exactly pushed for this act.

26. Flood Control Act 1917, *Laws of the United States*, v. 2, pp. 1703-1705.

27. Under this act, Congress directed the Corps to improve five levees on the upper Mississippi River in Illinois. These included the Hunt and Lima Lake levees that the Engineers had first worked on under the Warsaw to Quincy project, as well as levees in the Bay Island Drainage and Levee District No. 1, the Drury Drainage District, and the Henderson County Drainage District No. 3. The Corps improved or rebuilt these levees during the 1920s. See *WRD Illinois 1991*, pp. 40, 42, 45-46. Eleven years later, in the 1928 Flood Control Act, Congress directed the Corps to reinforce levees in six levee districts. In both the 1917 and 1928 Flood Control Acts, Congress limited levee work to the Mississippi River below Rock Island. Flood Control Act of 1928, *Laws of the United States*, v. 2, pp. 2004-07. This act "placed flood control on an equal footing with navigation improvement among the civil functions of the Corps." Jamie W. Moore and Dorothy P. Moore, *The Army Corps of Engineers and the Evolution of Federal Flood Plain Management Policy*, (Boulder: University of Colorado, Institute of Behavioral Science, 1989), p. 4.

28. The Meredosia Levee and Drainage District, encompassing some 10,000 acres, was the only significant levee district above Rock Island.

29. Flood Control Act of 1936, *Laws of the United States*, v. 3, pp. 2418-20.

30. The levee setback was for the reach between Beardstown, Illinois, and the mouth of the Illinois River. Flood Control Act of 1936, *Laws of the United States*, v. 3, p. 2421.

31. *Laws of the United States*, v. 3, 90th Cong., 1st Sess. House Doc. No. 182, pp. 2418-21, 2778, 2888. See U.S. Congress, House, 78th Cong. 2nd Sess., H. Doc. 651.

32. Tweet, *Rock Island District*, p. 295.

33. Philip V. Scarpino, *Great River: An Environmental History of the Upper Mississippi, 1890-1950*, (Columbia, 1985), chap 4.

34. U.S. Congress, House, *Hearings before the Committee on Agriculture on H.R. 4088*, "A Bill to Establish the Upper Mississippi River Wild Life and Fish Refuge," 68th Cong., 1st sess., February 11, 12, 13, 1924, (Washington, D.C., 1924), 35.

35. Will H. Dilg, "The Drainage Crime of a Century," Izaak Walton League Monthly 1:11 (July, 1923). On August 10, 1923, at the request of the Chief of Biological Survey, Oberholser inspected the area. Drainage advocates, according to Oberholser, planned to dredge and dike the main channel and drain the remaining land between the bluffs. He strongly recommended against the drainage project. See H.C. Oberholser, "The Winneshiek Drainage Project," *Iowa Conservation* 7 (1923):9-10; Scarpino, *Great River*, p. 131.

36. Scarpino, *Great River*, p. 135

37. Herbert Quick, *American Inland Waterways, Their Relation to Railway Transportation and to the National Welfare; Their Creation, Restoration and Maintenance*, (New York, 1909), p. 77. The 1920s farm crisis made farm organizations and farm equipment manufacturers some of the strongest supporters of navigation improvements during this decade.

38. Roald Tweet, *History of Transportation on the Upper Mississippi & Illinois Rivers*, (Washington, 1983), p. 77; Herbert Hoover, "The Improvement of Our Mid-West Waterways," *The Annals of the American Academy* 135 (January 1928), pp. 15-24; Idem., "Address at Louisville, Kentucky, October 23, 1929, in celebration of the Completion of the Nine-foot Channel of the Ohio River...." William Starr Myers, ed., *The State Papers and Other Public Writings of Herbert Hoover*, vol. 1 (New York, 1934), pp. 116-22; Franklin Snow, "Waterways as Highways," *North American Review* 227 (May 1929), p. 592.

39. John Anfinson, the author of the assessment's historical overview, has developed this argument extensively in a book that he is writing on the history of the upper river. Richard Hoops, in "A River of Grain: the Evolution of Commercial Navigation on the Upper Mississippi River," (Madison: University of Wisconsin Sea Grant Institute, nd) argues that a small clique of men pushed the 9-foot channel project through and that it was a pork barrel project. One must consider his argument carefully, but he underestimates the power, depth and expanse of the movement. Given the great interest and popular support for this project, it transcended simple pork barrel projects.

40. Scarpino, *Great River*, pp. 46-47.

41. John Anfinson has had an article accepted for publication in *Minnesota History*, Summer 1995, that examines the history of this project.

42. Raymond H. Merritt, *Creativity, Conflict & Controversy: A History of the St. Paul District, U.S. Army Corps of Engineers*. (Washington: U.S. Government Printing Office, 1979), p. 195; U.S. Congress, House, 69th Cong., 2d sess., H. Doc. 583.

43. U.S. Congress. House, "Mississippi River, Between Mouth of Missouri River and Minneapolis, Minn., Interim Report," 71st Cong., 2d sess., House Doc. 290, p. 37.

44. U.S. Congress, House, "Survey of the Mississippi River between Missouri River and Minneapolis," 72nd Cong. 1st sess., H. Doc. 137, p. 24.

45. "Mississippi River, Between Mouth of Missouri River and Minneapolis, Minn., Interim Report," H. Doc. 290, pp. 37, 45; "Survey of the Mississippi River between Missouri River and Minneapolis," H. Doc. 137, pp. 20-21. The report uses Muscatine, rather than Rock Island, as the point below which levees lined the river. I choose to use Rock Island to be consistent with the division I have made between the river above and below that city. Muscatine lies 27 miles below Rock Island.

46. Dobney, *River Engineers*, p. 102.

47. Moore and Moore, *Flood Plain Management*, pp. 35-36. White, p. 36, argued that the country had to change its pattern of floodplain occupation to "utilize most effectively the natural resources of the plain, and, at the same time, of applying feasible and practicable measures for minimizing the detrimental impacts of floods." He pushed for taking all alternatives into consideration, not just structural ones; see pp. 36-37.

48. Martin Reuss, "Coping with Uncertainty: Social Scientists, Engineers, and Federal Water Resources Planning," *Natural Resources Journal* 32:1 (Winter 1992):119.

49. The Corps was thinking about floodplain management problems at this time, however. At the American Forestry Association Meeting, in 1937, Assistant Chief of Engineers General Max C. Tyler said that greater storms or greater floods had not increased the flood control problem; more people using the floodplain had caused the problem. Moore and Moore, *Flood Plain Management*, p. 35.

50. Flood Control Act of 1946, *Laws of the United States*, v. 4, p. 3026; *WRD Illinois 1991*, pp. 47, 48.

51. U.S. Congress, House, "Illinois River, Ill.," H. Doc. 692, 77th Cong. 2d Sess.; U.S. Congress, House, H. Doc. 328, 77th Cong. 2nd Sess.; U.S. Congress, House, H. Doc. 651, 78th Cong. 2nd Sess.; U.S. Congress, House, H. Doc. 336, 77th Cong. 2nd Sess.; Flood Control Act of 1946, *Laws of the United States*, p. 2888-89; Tweet, *Rock Island District*, p. 297.

52. Des Moines is on the Des Moines River, Elkport is on Elk Creek and the Turkey River, and Galena is on the Galena River.

53. Flood Control Act of 1948, *Laws of the United States*, v. 4, p. 3102; *Water Resources Development in Minnesota 1993*, (St. Paul: U.S. Army Corps of Engineers, St. Paul District, 1993), p. 25; St. Paul District completed the Aitkin project in 1957.

54. Flood Control Act of 1950, *Laws of the United States*, v. 4, p. 3182; *Water Resources Development in Missouri 1991*, (St. Louis: U.S. Army Corps of Engineers, St. Louis District, 1991), pp. 8, 45.

55. Tweet, *Rock Island*, p, 306. Although recommended for construction, the Henderson County Drainage District No. 1 project was not authorized; see U.S. House, "Mississippi River--Guttenberg, Iowa, to Hamburg Bay, Illinois," H. Doc. 281, 83rd Cong., 2d Sess. These levees were included in a report entitled "Mississippi River--Guttenberg, Iowa, to Hamburg Bay, Illinois," all of which lies within the Rock Island District. Guttenberg itself lies within the St. Paul District, but the Rock Island District begins just below Lock and Dam No. 10 at Guttenberg.

56. Flood Control Act of 1954, *Laws of the United States*, v. 4, p. 3369. The act also recommended work on levees protecting agricultural lands in the tiny Fish Lake [Levee and Drainage District] on the Mississippi River near East St. Louis and on levees on the Upper Iowa River. Fish Lake has been incorporated into the Prairie du Pont Levee District. For details on the Sny Island project, see U.S. House, H. Doc. 247, 83d Cong. 2d, sess.

57. Flood Control Act of 1954, *Laws of the United States*, v. 4, p. 3368. See "Mississippi River--Guttenberg, Iowa, to Hamburg Bay, Illinois," H. Doc. 281, 83rd Cong., 2d Sess.

58. Flood Control Act of 1958, *Laws of the United States*, v. 4, pp. 3530-31.

59. Flood Control Act of 1958, *Laws of the United States*, v. 4, pp. 3530-31; U.S. House, "Rock and Green Rivers, Ill.," H. Doc. 173, 85th Cong., 1st Sess.; U.S. House, "Kaskaskia River, Ill.," H. Doc. 232, 85th Cong. 1st Sess.; *WRD Illinois* 1991, p. 81, the Carlyle project had been authorized under the 1938 Flood Control Act. See p. 82 for information on the Shelbyville dam and reservoir.

60. Elliott Mittler, Consultant, Public Policy and Natural Hazards, Adjunct Associate Professor, University of Southern California, Los Angeles, personal communication, April 1995, says that records he has examined show that Coralville was built to provide low flow augmentation for navigation on the Mississippi River.

61. Interagency Floodplain Management Review Committee, *Sharing the Challenge: Floodplain Management into the 21st Century*, (Washington, D.C.: U.S. Government Printing Office, June 1994), p. G1-4. This report is commonly known as the Galloway Report for Brigadier General Gerald E. Galloway, Executive Director of the Interagency Floodplain Management Review Committee.

62. Until 1936, the Corps and Congress had taken a levees only approach to flood control on the Mississippi River. This approach has been frequently criticized, especially since Charles Ellet Jr. had argued in 1851 that floodplain occupation was the cause of damages and that the Government should take a broader approach to preventing flood damage. In addition to levees, he suggested that the Government use headwaters reservoirs to trap or slow floodwaters on tributary rivers. Ten years later, Captain Andrew A. Humphreys and Lieutenant Henry L. Abbot insisted that levees alone would be enough. Congress and the Corps adopted Humphreys' "levee only" approach until the 1927 flood on the Mississippi River brought the program under severe criticism. See Moore and Moore, *Floodplain Management*, pp. 1-2; Shallot, *Structures in the Stream*, pp. 174-75.

This argument ignores the fundamental reason the Corps and Congress probably balked at Ellet's plan. Until the Federal Government formally entered flood control, it could do little other than build levees. It could argue that building levees aided navigation. To authorize and fund flood control reservoirs would have set a precedent that Congress was not ready to establish until the 1936 Flood Control Act.

63. Moore and Moore, *Flood Plain Management*, p. 3.

64. Moore and Moore, *Flood Plain Management*, p. 4; Dobney, *River Engineers*, p. 80.

65. Moore and Moore, *Flood Plain Management*, pp. 6, 8.

66. Demonstrating internal questions about flood control policy, Assistant Chief of Engineers, General Max C. Tyler, in a 1937 speech to the American Forestry Association Meeting, said that greater storms or greater floods had not increased the flood control problem; rather, more people using the floodplain had caused the problem. Moore and Moore, *Flood Plain Management*, p. 35.

67. Flood Control Act of 1938, *Laws of the United States*, v. 3, p. 2600. Reuss, "Coping with Uncertainty," pp. 118-119, shows that the act took this language almost verbatim from a report entitled *Drainage Basin Problems and Programs*. Harlan Barrows had chaired a subcommittee on the Ohio River and lower Mississippi River which provided this input for the report.

68. Moore and Moore, *Flood Plain Management*, p.15. Elliott Mittler, personal communication, April 1995, points out that the Red Cross had begun trying to move people out of the floodplain well before this time.

69. Moore and Moore, *Flood Plain Management*, p. 40.

70. Moore and Moore, *Flood Plain Management*, p. 41; they contend that "Human invasion of the flood plain was the persistent and dominant characteristic of postwar urbanization of American society." See p. 45.

71. Moore and Moore, *Flood Plain Management*, pp. 46, 47.

72. Moore and Moore, *Flood Plain Management*, p. 42.

73. Moore and Moore, *Flood Plain Management*, p. 48.

74. Moore and Moore, *Flood Plain Management*, p. 53; Merritt, *Creativity*, pp. 49-50. They say, p. 49, that "Flood plain management entered the federal agenda formally when the Tennessee Valley Authority transmitted its publication, *A Program for Reducing the National Flood Damage Potential*, to the president in September 1958." They add, p. 49, that "The program's central message was that the traditional approach of federal agencies to flood problems encouraged flood plain occupancy and thereby increased the total flood damage each year."

75. Marty Reuss, personal communication, 21 March 1995.

76. Moore and Moore, *Flood Plain Management*, pp. 66-67; One floodplain management scholar would later refer to this study as the "Magna Carta of contemporary nonstructural flood plain management planning...[it] provided the impetus...toward a unified flood plain management program."

p. 72 Despite this accolade, White says that the Federal Insurance Administration never really made the "wise use" concept a Federal objective. White's comments came in a FAX containing his comments on the draft Floodplain Management Assessment, May 5, 1995, Gilbert F. White to David Loss, Corps of Engineers, St. Paul District.

77. Moore and Moore, *Flood Plain Management*, p. 71.

78. Moore and Moore, *Flood Plain Management*, p. 75.

79. Moore and Moore, *Flood Plain Management*, pp. 64-65.

80. Moore and Moore, *Flood Plain Management*, pp. 105-06, quote p. 132.

81. Moore and Moore, *Flood Plain Management*, p. 134.

82. Robert L. Branyan, *Taming the Mighty Missouri: A History of the Kansas City District* (Washington, D.C.: U.S. Government Printing Office, 1974), p. 9; *The Federal Engineer: Damsites to Missile Sites, A History of the Omaha District* (no author or publisher, 1980), p. 17. These two works were the major sources used for this overview of navigation and flood control on the Missouri River.

83. Because so little traffic plied the Missouri River, Congress asked for a restudy of the project as early as 1915.

84. *Federal Engineer*, pp. 12-13.

85. Branyan, *Mighty Missouri*, p. 64.

86. U.S. Congress, House of Representatives, H. Doc. 238, 73rd Cong., 2nd sess., 1935.

87. Branyan, *Mighty Missouri*, pp. 64-67.

88. Branyan, *Mighty Missouri*, pp. 66-68.

89. Branyan, *Mighty Missouri*, pp. 69-71.

90. Branyan, *Mighty Missouri*, pp. 71-73.

91. Branyan, *Mighty Missouri*, pp. 76-79.

92. Branyan, *Mighty Missouri*, pp. 82-86.

93. *Federal Engineer*, pp. 231-233.

94. *Federal Engineer*, pp. 239-253.

ATTACHMENT 4

CRITICAL FACILITIES INVENTORIES

Enclosed are lists of critical facilities for each of the five Corps of Engineers Districts that were affected by the 1993 Midwest flood.

Omaha District	page ATT 4-2
Kansas City District	page ATT 4-5
St. Paul District	page ATT 4-9
Rock Island District	page ATT 4-11
St. Louis District	page ATT 4-14

It has been pointed out in the report that the existing information and data bases did not allow development of a comprehensive inventory of critical facilities subject to flood risk, nor to estimate costs to satisfactorily protect or relocate such facilities from flooding. The following tables list the approximately 630 facilities that were identified as being impacted by the flood of 1993. Included following the list from each District is a summary of the quality, format, and coverage of those data sets.

It should also be noted that the availability of critical facility data and the ease with which it is obtained varies considerably among communities, states, and agencies, all of which define, collect, store, and update such data in different ways. For example, the EPA has extensive information on impacted critical facilities from the 1993 flood. Because we could not reconcile all the differences between this data, as well as other data sources, relative to our specific study area, our numbers are probably smaller than may be seen described in other references which likely cover a larger flood impact zone. However, we have attempted to incorporate this data to the extent possible. This was most easily done if the data was in a digital GIS format. We acknowledge that a substantial amount of work remains to be accomplished to develop a comprehensive inventory of critical facility information. Hopefully the data compiled for the FPMA can be used by other interested parties as a building block to develop such a comprehensive database.

Omaha District Critical Facilities Inventory			
Designation	Facility Identification	State Name	County Name
npdes[1]	IA0043095	Iowa	Woodbury
npdes	IA0004014	Iowa	Woodbury
npdes	IA0004103	Iowa	Woodbury
npdes	IA0061859	Iowa	Woodbury
npdes	NE0021482	Nebraska	Washington
npdes	NE0000418	Nebraska	Washington
npdes	IA0004308	Iowa	Pottawattamie
npdes	IA0036641	Iowa	Pottawattamie
npdes	NE0036307	Nebraska	Sarpy
npdes	NE0112810	Nebraska	Sarpy
npdes	NE0001040	Nebraska	Sarpy
npdes	NE0021245	Nebraska	Otoe
npdes	NE0001244	Nebraska	Nemaha
npdes	IA0021946	Iowa	Mills
npdes	NE0111635	Nebraska	Otoe
landfill	SHAW AVENUE DUMP	Iowa	Woodbury
wwt[2]	CONSUMER LIMESTONE PRODUCTS CO.	Iowa	Mills
wwt	BLUFF VIEW MOTEL/CAFE/AMOCO	Iowa	Mills
wwt	CONSUMER LIMESTONE PRODUCTS CO.	Iowa	Fremont
wwt	MANILDRA ENERGY CORPORATION	Iowa	Fremont
wwt	MANILDRA ENERGY CORPORATION	Iowa	Fremont
Substation		Nebraska	Sarpy
Substation		Nebraska	Cass
Powerplant	diesel	Nebraska	Otoe
Powerplant	steam	Nebraska	Otoe
Substation		Nebraska	Nemaha
airport	Garst Airport	Missouri	Atchison
airport	Rock Port Municipal Airport	Missouri	Atchison
school	Shandy School	Missouri	Atchison
school	Pleasant Valley School	Missouri	Atchison
school	Union School (historical)	Missouri	Atchison
school	Cooper School (historical)	Missouri	Atchison
school	Langdon School (historical)	Missouri	Atchison
school	Lincoln School (historical)	Missouri	Atchison
school	Sunny Grove School (historical)	Missouri	Atchison
school	Excelsior School (abandoned)	Missouri	Atchison

Table MRO-1 (con't) Critical Facilities Inventory			
school	Cox Chapel School (abandoned)	Missouri	Atchison
school	Lewis School (historical)	Missouri	Atchison
school	Ellison School (abandoned)	Missouri	Atchison
school	Bend Center School (historical)	Missouri	Atchison
school	Cottonwood Grove School(historical)	Missouri	Atchison
Designation	Facility Identification	State Name	County Name
school	Phelps City School (historical)	Missouri	Atchison
school	Belleview School (historical)	Missouri	Atchison
school	Marietta School (abandoned)	Missouri	Holt
school	Lake Shore School (abandoned)	Missouri	Holt
school	Eureka School No 1	Iowa	Mills

[1] National Pollution Discharge Elimination System
[2] Waste Water Treatment Plant

Dataset Description

OMAHA DISTRICT Critical Facilities	Coverage	Format	Locational Information	Accuracy (FEET)	Source Date	Source
Municipal & Industrial NPDES	1	1	GIS	?	?	5
Superfund Sites	1	1	GIS	?	?	5
Landfills	1	1	GIS	?	?	5
Hazardous Waste Facilities						
PetroChemical and Major Pipeline	1	1	GIS	n/a	83	6
Water Treatment Plants	1	1	GIS	60	80	4
Major Water Supply Intakes	1	1	GIS	60	80	4
Water Well Fields	1	1	GIS	60	80	4
Sewage Treatment Plants	1	1	GIS	60	80	4
Power Plants	1	1	GIS	60/1000	'80/92	4,8
Hospitals	1	1	GIS	60	'80/92	3,4
Group Homes						
Schools	1	1	GIS	60	'80/92	3,4
Federal and State Bridges	1	1	GIS	250	88	7
Prisons						
Airports	1	1	GIS	10?	94	6
Police and Fire Departments						

Coverage	Format	Locational Information (If non-GIS)
1 - FPMA Study Area Floodplain	1 - Digital Spatial (GIS)	1 - SECT/TWN/RANGE
2 - 1993 Flood Zone	2 - Digital Non-spatial (spreadsheet)	2 - STREET ADDRESS
3 - Only Portions of study area	3 - Paper	3 - City/County
		4 - River Mile

SOURCES

1 - Field Survey as part of 1993 Flood Damage Collection
2 - Missouri River Basin Atlas
3 - Geographic Names Information System (GNIS-Date Unknown)
4 - Missouri River Basin States Association Atlas (1982) - KARS
5 - Environmental Protection Agency
6 - Rock Island and Omaha District COE (Iowa FEMA Project)
7 - Census Bureau TIGER Data
8 - Western Area Power Administration

KANSAS CITY DISTRICT Critical Facilities

RIVER MILE	2	COUNTY	FACILITY TYPE	FACILITY NAME	DAMAGES
450-451	MO	Buchanan	1	Rosecrans Memorial Airport	$7,400,000
386	MO	Platte	1	Waldron Airport	$100,000
386	MO	Platte	1	Noahs Ark Airfield (12 Planes @50,000)	$600,000
367	MO	Clay	1	Kansas City Municipal Airport	$4,000,000
344	MO	Clay	1	Liberty Landing Airport	$150,000
319	MO	Ray	1	Lexington Airport	$60,000
290	MO	Carroll	1	Carrollton Airport	$171,000
	MO	Callaway	1	Jefferson City Airport	$1,125,000
498.1	MO/NE	Holt/Richardson	2	Rulo Highway Bridge	
448.2	MO/KS	Buchanan/Doniphan	2	Union Pacific RR Bridge	
447.9	MO/KS	Buchanan/Doniphan	2	St. Joseph Highway Bridge	
422.5	MO/KS	Buchanan/Atchison	2	Atchison RR Bridge	
422.5	MO/KS	Buchanan/Atchison	2	Atchison Highway Bridge	$384,000
397.6	MO/KS	Platte/Leavenworth	2	Leavenworth Highway Bridge	
396.7	MO/KS	Platte/Leavenworth	2	C. & N. W.RR Bridge	
374.1	MO/KS	Platte/Wyandotte	2	Interstate 635 Highway Bridge	$1,500,000
372.6	MO/KS	Platte/Wyandotte	2	Fairfax Highway Bridge	
372.6	MO/KS	Platte/Wyandotte	2	Platte Purchase Highway Bridge	
366.2	MO/MO	Clay/Jackson	2	Broadway Bridge	
366.1	MO/MO	Clay/Jackson	2	Hannibal Highway Bridge	
365.7	MO/MO	Clay/Jackson	2	A. S. B. Bridge	
364.8	MO/MO	Clay/Jackson	2	Paseo Bridge	
362.3	MO/MO	Clay/Jackson	2	Chouteau Bridge	
360.3	MO/MO	Clay/Jackson	2	Interstate 435 Highway Bridge	
359.4	MO/MO	Clay/Jackson	2	Harry S. Truman Highway Bridge	
352.7	MO/MO	Clay/Jackson	2	Liberty Bend Cut-off Bridge	
336.2	MO/KS	Ray/Jackson	2	A. T. & S. F. RR Bridge	
317.3	MO/KS	Ray/Lafayette	2	Lexington Highway Bridge	$76,000
293.4	MO/MO	Carroll/Lafayette	2	Waverly Highway Bridge	
262.6	MO/MO.	Carroll/Saline	2	Miami Highway Bridge	
226.3	MO/MO	Howard/Saline	2	Glasgow Highway Bridge	$4,826,000
226.3	MO/MO	Howard/Saline	2	Illinois Central Gulf RR Bridge	$4,100,000
197.1	MO/MO	Howard/Cooper	2	M. K. T. RR Bridge	
196.6	MO/MO	Howard/Cooper	2	Boonville Highway Bridge	
185	MO/MO	Boone/Cooper	2	Rocheport Highway Brigde	
143.9	MO/MO	Callaway/Cole	2	Jefferson City Highway Bridge	$750,000
97.9	MO/MO	Montgomery/Gasconade	2	Hermann Highway Bridge	$1,668,900
67.6	MO/MO	Warren/Franklin	2	Washington Highway Bridge	$458,000
344	MO	Clay	3	United Telephone Co - Missouri City	$2,000
Platte River	MO	Buchanan	4	Agency, Missouri	???
448	KS	Doniphan	4	Elwood, Kansas	$25,300

386	MO	Platte	4	Waldron, Missouri	$50,000
377.5	MO	Platte	4	Parkville, Missouri	???
372	MO	Platte	4	Riverside, Missouri	$100,000
344	MO	Clay	4	Missouri City, Missouri	$20,000
334	MO	Ray	4	Orrick, Missouri	$3,000
270	MO	Carroll	4	Wakenda, Missouri	$50,000
197	MO	Howard	4	Franklin, Missouri	$13,500
120	MO	Callaway	4	Steedman, Missouri	$1,200
118	MO	Osage	4	Chamois, Missouri	$500
109	MO	Gasconade	4	Morrison, Missouri	$10,000
73	MO	Warren	4	Marthasville, Missouri	???
455.4	MO/KS	Andrew/Doniphan	5	Williams Brothers Pipeline Co	$300,000
452.2	MO	Buchanan	5	Water Supply and Treatment Plant-St. Joseph	
449.1	MO	Buchanan	5	Edmond Street Power Generating Station - St. Joseph P&L Company	
446.4	MO	Buchanan	5	Waste Water Treatment Plant - St. Joseph	
446-48	MO	Buchanan	5	Seitz Foods Inc.-Armour & Co.	
446-448	MO	Buchanan	5	Wire Rope Co - McGraw Edison - MO Chemical (S. St. Joseph Ind. Dist)	
445.7	KS	Doniphan	5	Waste Water Treatment - Elwood	
445.6	MO	Buchanan	5	Waste Water Treatment Plant - South St. Joseph Industrial District	
420	MO	Platte	5	Waste Water Treatment - Atchison	
410.9	MO	Platte	5	Iatan Power Generating Station- KC P&L - St Joseph P&L - Empire Dist.	
392	KS	Leavenworth	5	Kansas State Penitentiary Farm - Leavenworth	
392	KS	Leavenworth	5	Waste Water Treatment Plant - Lansing	
386.1	MO	Platte	5	Water Supply and Treatment Plant-near Waldron	
386.1	KS	Leavenworth	5	Water Supply Treatment Plant near Waldron	
375.7	MO	Platte	5	Intercontinental Engineering Mfg. - Parkville	
365.7	MO	Jackson	5	Grand Avenue Power Generating Station Intake	
334	MO	Clay	5	Water Supply Treatment Plant-Orrick	
226.7	MO	Howard	5	Water Intake and Treatment Plant-Glasgow	
	KS	Leavenworth	6	Sherman Army Airfield	$350,000
	MO	Buchanan	6	National Guard Facility - Rosecrans-St Joseph	$17,000,000
	MO	Callaway	6	National Guard Facility - Jefferson City	$616,000
452.2	MO	Buchanan	7	Water Intake and Treatment Plant-St. Joseph	???
449.1	MO	Buchanan	7	Edmond Street Power Generating Station Intake-St. Jose	???
445.9	MO	Buchanan	7	Lake Road Power Generating Station Intake-St. Joseph	???
421.8	KS	Atchison	7	Water Intake and Treatment Plant-Atchison	???
411.1	MO	Platte	7	Iatan Power Generating Station Intake-St. Joseph Power	???
370.5	MO	Clay	7	Water Intake and Treatment Plant-Kansas City Board of	???
452.2	MO	Buchanan	8	Missouri American Water - St Joseph	$650,000
445.9	MO	Buchanan	8	Lake Road Power Generating Station - St. Joseph Power	$924,000
411.1	MO	Platte	8	Iatan Power Station	$2,500,000
403.5	MO	Platte	8	Waste Water Treatment - Weston	$4,200

KANSAS CITY DISTRICT Critical Facilities

397.6	KS	Leavenworth	8	Water Supply and Treatment Plant-Leavenworth	$100,000
395.6	KS	Leavenworth	8	Waste Water Treatment Plant - Leavenworth	$500,000
378.7	KS	Wyandotte	8	Nearman Power Generating Station - Kansas City-Kansa	$1,500,000
373.4-.5	KS	Wyandotte	8	Quindaro Power Generating Station and Water Supply an	$11,000,000
370.5	MO	Clay	8	Water Supply and Treatment Plant-Kansas City	$960,000
353.3	MO	Jackson	8	Independence Water Intake and Treatment Plant-Missour	$134,923
317	MO	Lafayette	8	Water Supply and Treatment Facilities-Lexington	$25,000
225.4	MO	Howard	8	Glasgow Wastewater Treatment	$108,000
197.1	MO	Cooper	8	Water Supply and Treatment Plant-City of Boonville	$34,000
151	MO	Cole	8	Missouri State Prison Farm - Renz	???
144	MO	Cole	8	Capitol City Water Intake and Treatment Plant-Jefferson	$116,000
117.1	MO	Osage	8	Central Electric Coop - Chamois Power	$556,000
	MO	Callaway	8	Jefferson City Waste Water Treatment Plant	$173,200
	KS	Doniphan	8	Elwood Wastewater Treatment	???
344	MO	Clay	9	Missouri City Fire Department	$2,600
334	MO	Ray	9	Orrick Fire Department	$5,000
	MO	Clay/Ray	9	Excelsior Springs	
345.3	MO	Clay	10	Missouri City Power Station	$126,000
	MO	Gasconade	10	Hermann Electric Substation	$170,000
145-147	MO	Cole	11	Renz Farm of Division of Corrections (Missouri State Pris	???
142.6	MO	Cole	11	Missouri State Prison	$8,000,000
Fishing River	MO	Clay	12	Roosevelt Elementary	???
344	MO	Clay	12	Missouri City Elementary	$350,000
334	MO	Ray	12	Orrick Grade School	???
334	MO	Ray	12	Orrick Elementary	???
334	MO	Ray	12	Orrick High School	$850,000
313	MO	Ray	12	Hardin School	$188,000
270	MO	Carroll	12	Wakenda School	$100,000
102 River	MO	Andrew	12	North Andrew High School	$10,000
365.7	MO	Jackson	13	Grand Avenue Power Generating Station Intake	
	MO	Warren	13	Marthasville Wastewater Treatment	$5,000
	MO	Howard	13	New Franklin Wastewater Treatment	$12,400
	MO	Platte	13	Platte City Wastewater Treatment	$10,000
452.2	MO	Buchanan	14	Water Supply and Treatment Plant-St. Joseph	
421.8	KS	Atchison	14	Water Intake and Treatment Plant-Atchison	
386.1	MO	Platte	14	Water Supply and Treatment Plant-near Waldron	
370.5	MO	Clay	14	Water Supply and Treatment Plant-Kansas City	
334	MO	Clay	14	Water Supply Treatment Plany-Orrick	
318-319	MO	Lafayette	14	Well Field and Treatment Plant-Richmond	
226.7	MO	Howard	14	Water Intake and Treatment Plant-Glasgow	
176-179	MO	Boone	14	Well Field and Treatment Plant-Columbia	
097-098	MO	Gasconade	14	Well Field and Treatment Plant-Hermann	

68	MO	Warren	14	Well Field and Treatment Plant-Washington	$250,000
	MO	Andrew	14	Bolckow Water Plant (102 River)	$500
	MO	Boone	14	McBaine Water Plant	$6,000
507	MO	Holt	15	Craig-Well	
498	NE	Richardson	15	Rulo-Well	
497	NE	Richardson	15	Falls City Municipal Well Field-Rulo	
488	KS	Doniphan	15	White Cloud-Well	
482-485	MO	Holt	15	Oregon and Forest City-Wells	$1,200
460	MO	Andrew	15	Amazonia-Wells	
448	KS	Doniphan	15	Elwood-Wells	
442	KS	Doniphan	15	Wathena-Wells	???
428	MO	Buchanan	15	Rushville-Wells	$500,000
403-4	MO	Platte	15	Weston-Wells	$46,000
399.5	KS	Leavenworth	15	Fort Leavenworth Military Reservation-Wells	
391	MO	Platte	15	PWSD No. 1-Wells near Farley	
313	MO	Ray	15	Hardin Wells	$2,000
293	MO	Lafayette	15	Waverly Well Field	$45,000
287	MO	Carroll	15	Carroll Waste Water Treatment Plant	$60,000
286	MO	Carroll	15	Carrollton Well Field	$88,000

NOTES: A blank in the Damages Column indicates that it is not known if the facility suffered 1993 flood damage.
??? indicates damages are known to have occurred but a dollar value was not available.

FACILITY TYPE

1 MAJOR AIRPORTS
2 STATE OR FEDERAL BRIDGES
3 COMMUNICATION EQUIPMENT
4 FEDERAL POST OFFICES
5 HAZARDOUS MATERIALS, PRODUCTION, STORAGE, & WASTE FACILITIES - MUNICIPAL AND INDUSTRIAL NPDES
6 MILITARY INSTALLATION
7 MAJOR WATER SUPPLY INTAKES
8 MUNICIPAL & INDUSTRIAL NPDES
9 POLICE & FIRE DEPARTMENTS
10 POWER PLANTS
11 PRISONS
12 SCHOOLS
13 SEWAGE TREATMENT PLANTS
14 WATER TREATMENT PLANTS
15 WATER WELL FIELDS

ST. PAUL DISTRICT **Critical Facilities**	**INVENTORY**
Municipal & Industrial NPDES	None
Superfund Sites	Burnsville, MN (Dakota Co.) Freeway Sanitary Landfill, Superfund National Priority List (NPL) Site, 126 acres site 400 feet from Minnesota River
	Twin Cities Air Force Reserve Base (Hennepin Co.), Int'l. Airport Complex, Small arms range landfill, 3 acre site along Minnesota River within 100 year floodplain.
Landfills	
Hazardous Waste Facilities	
PetroChemical and Major Pipelines	Durand, WI (Pepin Co.) Oil spill from fuel barrels at Pomosl Motors Bldg. (minor, contained in immediate area).
Water Treatment Plants	LeSueur, MN (LeSueur Co.) Water treatment plant shut down.
Major Water Supply Intakes	None
Water Well Fields	None
Sewage Treatment Plants	Osseo, WI (Trempealeau Co.) Wastewater treatment plant flooded.
	St. Peter, MN (Nicollet Co.) Sewage treatment plant shut down.
Power Plants	None
Hospitals	None
Group Homes	None
Schools	None
Federal and State Bridges	U.S./State/County Highway Bridge closures over Minnesota River at:
	Highway 22, St. Peter, Nicollet/LeSueur Counties
	Highway 99, St. Peter, Nicollet/LeSueur Counties
	Highway 93, LeSueur, LeSueur/Sibley Counties
	Highway 19, Henderson, Sibley/LeSueur Counties
	Highway 60, Blakely, Sibley/Scott Counties
	Highway 45, Jordan, Scott/Carver Counties
	Highway 41, Chaska, Carver/Scott Counties
	Highway 169, Shakopee, Scott/Hennepin Counties
	LeSueur, MN (LeSueur Co.) Chicago & Northwestern rail line along Minnesota River closed
Prisons	None
Airports	Holman Field, St. Paul, MN, downtown St. Paul airport shut down 14 days (Ramsey Co.) .
Police and Fire Departments	None

Dataset Description

ST. PAUL DISTRICT Critical Facilities	Coverage	Format	Locational Information	Accuracy (FEET)	Source Date	Source
Municipal & Industrial NPDES						
Superfund Sites	3	1	GIS	150	1994	3,7
Landfills						
Hazardous Waste Facilities	1	1	GIS	150	1994	4
PetroChemical and Major Pipeline	1	1	GIS	?	1994	4,5
Water Treatment Plants	3	3	3		1993	5,6
Major Water Supply Intakes	3	1	GIS	150	1994	4
Water Well Fields						
Sewage Treatment Plants	3	3	3		1993	6
Power Plants						
Hospitals						
Group Homes						
Schools						
Federal and State Bridges	1	1	GIS	250		2,6
Prisons						
Airports	1	1	GIS	60		1,6
Police and Fire Departments						

Coverage	Format	Locational Information (If non-GIS)
1 - FPMA Study Area Floodplain	1 - Digital Spatial (GIS)	1 - SECT/TWN/RANGE
2 - 1993 Flood Zone	2 - Digital Non-spatial (spreadsheet)	2 - STREET ADDRESS
3 - Only Portions of study area	3 - Paper	3 - City/County
		4 - River Mile

SOURCES

1 - FAA
2 - US Dept of Transportation
3 - US EPA Region 7
4 - Environmental Management Technical Center
5 - Newspaper press reports at time of flooding, Minneapolis Star Tribune and St. Paul Pioneer Press
6 - The Great Flood of 1993 Post Flood Report, Appendix A, St. Paul District. September 1994
7 - Superfund: Progress at National Priority List Sites, EPA 905-R-94-018, May 1994

Rock Island District Critical Facilities

Critical Facilities	Number and Location
Toxic Release	2 Sites - Adams County, IL
	1 Site - Rock Island County, IL
	2 Sites - Lee County, IA
	1 Site - Muscatine County, IA
	1 Site - Polk County, IA
	2 Sites - Marion County, MO
NPDES	No Sites
Landfills	No Sites
Power Plants	1 Site - Clayton County, IA
Substations	1 Site - Clayton County, IA
	1 Site - Des Moines County, IA
	1 Site - Louisa County, IA
Water Wells	2 Sites - Adams County, IL
	4 Sites - Henderson County, IL
	4 Sites - Rock Island County, IL
	2 Sites - Clayton County, IA
	1 Site - Jackson County, IA
	3 Sites - Mahaska County, IA
	1 Site - Wapello County, IA
Surface Water Intakes	1 Site - Adams County, IL
	2 Sites - Henderson County, IL
	1 Site - Hancock County, IL
	1 Site - Des Moines County, IA
	2 Sites - Lee County, IA
	1 Site - Marion County, IA
	3 Sites - Polk County, IA
	3 Sites - Wapello County, IA
Hospitals	Guttenberg Municipal Hospital, Guttenberg, IA
Schools	Guttenberg Community Jr-Sr High School, Guttenberg, IA
	Guttenberg Community School District, Guttenberg, IA
	Guttenberg Elementary School, Guttenberg, IA
	Sabula Elementary Center, Sabula, IA
	Sabula Middle School, Sabula, IA
	St. Mary's School, Guttenberg, IA
Airports	Meeker, Warsaw, IL
	Schnelle, Ursa, IL
	The Adwell Corporation, Meyer, IL
	GAA Private, Guttenberg, IA
	Cyanamid-Hannibal, Hannibal, MO
	Haerr Field, Taylor, MO

Rock Island District Critical Facilities

Prisons	No Sites
Railroad Bridges	1 Site - Adams County, IL
	1 Site - Henderson County, IL
	1 Site - Lee County, IA
	3 Sites - Polk County, IA
	2 Sites - Wapello County, IA
	1 Site - Marion County, MO
	1 Site - Pike County, MO
Highway Bridges	1 Site, Route 24, Adams County, IL
	1 Site, Route 57, Adams County, IL
	1 Site, Route 96, Calhoun County, IL
	2 Sites, Route 96, Hancock County, IL
	2 Sites, Route 34, Henderson County, IL
	4 Sites, Route 36, Pike County, IL
	2 Site, Route 54, Pike County, IL
	1 Site, Route 96, Pike County, IL
	1 Site, Route 22, Rock Island County, IL
	2 Sites, Route 61, Rock Island County, IL
	1 Site, Route 67, Rock Island County, IL
	1 Site, Route 84, Rock Island County, IL
	1 Site, Route 92, Rock Island County, IL
	2 Sites, Route 280, Rock Island County, IL
	2 Sites, Route 52, Clayton County, IA
	1 Site, Route 2, Lee County, IA
	1 Site, Route 61, Lee County, IA
	1 Site, Route 136, Lee County, IA
	4 Sites, Route 61, Louisa County, IA
	2 Sites, Route 99, Louisa County, IA
	1 Site, Route 92, Mahaska County, IA
	1 Site, Route 137, Mahaska County, IA
	2 Sites, Route 14, Marion County, IA
	1 Site, Route 6, Polk County, IA
	2 Sites, Route 35, Polk County, IA
	1 Site, Route 2, Van Buren County, IA
	3 Sites, Route 23, Wapello County, IA
	2 Sites, Route 34, Wapello County, IA
	1 Site, Route 137, Wapello County, IA
	1 Site, Route 46, Warren County, IA
	3 Sites, Route 61, Clark County, MO
	1 Site, Route 61, Lewis County, MO
	5 Sites, Route 24, Marion County, MO
	1 Site, Route 36, Marion County, MO
	2 Sites, Route 61, Marion County, MO

Dataset Description

ROCK ISLAND DISTRICT Critical Facilities	Coverage	Format	Locational Information	Accuracy (FEET)	Source Date	Source
Municipal & Industrial NPDES	3	1	GIS	150		2
Superfund Sites	3	1	GIS	150		6
Landfills	3	1	GIS	60		1,2
Hazardous Waste Facilities	1	1	GIS	150		6,7
PetroChemical and Major Pipeline						
Water Treatment Plants						
Major Water Supply Intakes	3	1	GIS	150		1,2
Water Well Fields	3	1	GIS	150		1,2
Sewage Treatment Plants						
Power Plants	3	1	GIS	250		4
Hospitals	3	1	GIS	60		1,2
Group Homes						
Schools	3	1	GIS	60		1
Federal and State Bridges	1	1	GIS	250		5
Prisons	3	1	GIS	60		1
Airports	1	1	GIS	60		3
Police and Fire Departments						

Coverage	Format	Locational Information (If non-GIS)
1 - FPMA Study Area Floodplain	1 - Digital Spatial (GIS)	1 - SECT/TWN/RANGE
2 - 1993 Flood Zone	2 - Digital Non-spatial (spreadsheet)	2 - STREET ADDRESS
3 - Only Portions of study area	3 - Paper	3 - City/County
		4 - River Mile

SOURCES

1 - State of Iowa

2 - State of Illinois

3 - FAA

4 - Omaha District

5 - US Dept of Transportation

6 - US EPA Region 7

7 - US EPA Region 5

ST. LOUIS DISTRICT

Critical Facilities	INVENTORY	SOURCE
Municipal & Industrial NPDES		
Superfund Sites		
Landfills		
	Chain of Rocks Disposal Facility - Granite City, Il	
	Milan Disposal Facility - Fairmont City, IL	
Hazardous Waste Facilities		
	11 sites - St. Clair County, IL	1
	23 sites - Madison County, IL	1
	1 site - Trojan Powder Co., Union County, IL	1
	10 sites - St. Louis, MO	5
	1 site - Pevely, MO	5
	1 site - Clarksville, MO	5
	1 site - Scott City, MO	5
	1 site - Cape Girardeau, MO	5
	1 site - Festus, MO	5
	1 site - Louisiana, MO	5
PetroChemical and Major Pipelines		
	American Refining Group, Hartford, IL	6
	APEX Oil Company, Granite City, IL	6
	Clark Oil Company, Alton, IL	6
	Mobile Oil Corp., Sauget, IL	6
	Amoco Oil Company, Woodriver, IL	6
	Phillips Pipeline Co., Cahokia, IL	6
	Miss. R.M. 197 - Cherokee Pipeline Co. - 5-10" Oil pipeline	2
	Miss. R.M. 196 - Continental Pipeline Co - 2-10" pipelines	2
	Miss. R.M. 175 - Explorer Pipeline Co. - 1-14" Refined petro.	2
	Miss. R.M. 196 - Explorer Pipeline Co. - 1-24" Refined petro.	2
	Miss. R.M. 215 - Gulf Pipeline Co. - 2-8" Petro prod.	2
	Miss. R.M. 153 - Gulf Pipeline Co. - 2-10" Oil	2
	Miss. R.M. 184 - Laclede Pipeline Co. - 1-10" Propane gas	2
	Miss. R.M. 192 - Laclede Pipeline Co. - 1-10" Propane gas	2
	Miss. R.M. 172 - Miss. River Fuel Corp - 2-10" Natural gas	2

ST. LOUIS DISTRICT

	Miss. R.M. 183 - Miss. River Fuel Corp - 2-10" Natural gas	2
	Miss. R.M. 127 - Miss. River Trans Corp - 4-10" Natural gas	2
	Miss. R.M. 127 - Miss. River Trans Corp - 2-25" Natural gas	2
	Miss. R.M. 167 - Miss. River Trans Corp - 4-10" Natural gas	2
	Miss. R.M. 171 - Miss. River Trans Corp - 8-10" Natural gas	2
	Miss. R.M. 183 - Miss. River Trans Corp - 1-10" Gas	2
	Miss. R.M. 184 - Miss. River Trans Corp - 1-10" Natural gas	2
	Miss. R.M. 191 - Miss. River Trans Corp - 2-12" Natural gas	2
	Miss. R.M. 176 - Mobile Oil Co. - 2-8" and 1-4" pipelines	2
	Miss. R.M. 176 - Mobile Oil Co. - 1-6" Gasoline	2
	Miss. R.M. 108 - Mobile Pipeline Co. - 1-20" Crude oil	2
	Miss. R.M. 109 - Mobile Pipeline Co. - 1-20 Crude oil	2
	Miss. R.M. 80 - Natural Gas Pipeline Co of America - 2-30" Nat gas	2
	Miss. R.M. 81 - Natural Gas Pipeline Co of America - 3-20" Nat gas	2
	Miss. R.M. 283 - Panhandle Eastern Pipeline Co - 1-22" natural gas	2
	Miss. R.M. 283 - Panhandle Eastern Pipeline Co - 4-12" natural gas	2
	Miss. R.M. 284 - Panhandle Eastern Pipeline Co - 2-24" natural gas	2
	Miss. R.M. 284 - Panhandle Eastern Pipeline Co - 1-30" natural gas	2
	Miss. R.M. 171 - Phillips Petroleum Co - 1-20" and 2-8" Petro prod	2
	Miss. R.M. 196 - Platte Pipeline Co - 1-12" and 1-20" Crude oil	2
	Miss. R.M. 198 - Service Pipeline Co - 2-12" Petro products	2
	Miss. R.M. 183 - Shell Pipeline Co - 1-6" Refined petro. prod.	2
	Miss. R.M. 192 - Shell Pipeline Co - 1-8" Natural gas	2
	Miss. R.M. 192 - Shell Pipeline Co - 2-10" Oil	2
	Miss. R.M. 197 - Shell Pipeline Co - 2-22" Crude Oil	2
	Miss. R.M. 197 - Sinclair Refining Co - 2-18" pipelines	2
	Miss. R.M. 178 - Socony-Vacuum Oil Co - 1-8" pipeline	2
	Miss. R.M. 46 - Texas Eastern Trans Corp - 2-24" Petro. Prod.	2
	Miss. R.M. 46 - Texas Eastern Trans Corp - 1-20" Petro. Prod.	2
	IL R.M. 31 - Central IL Public Service Co - 2-4" Gas pipelines	2
	IL R.M. 43 - Central IL Public Service Co - 2-4" Gas pipelines	2
	IL R.M. 70 - Central IL Public Service Co - 2-4" Gas pipelines	2
	IL R.M. 49 - Panhandle Eastern Pipeline Co - 1-30" Natural gas	2
	IL R.M. 49 - Panhandle Eastern Pipeline Co - 1-24" Gas pipeline	2
	IL R.M. 49 - Panhandle Eastern Pipeline Co - 5-10" Gas pipelines	2
	IL R.M. 49 - Panhandle Eastern Pipeline Co - 4-12" Gas pipelines	2
	IL R.M. 70 - Texaco-Cities Serv. Pipeline Co - 2-12" Crude oil	2

ST. LOUIS DISTRICT

Water Treatment Plants		
	1 site - Alton, IL - Madison County, IL	3
	1 site - Baldwin, IL - Randolph County, IL	3
	1 site - Central Alexander County Water District - Alexander County, IL	3
	1 site - Grafton, IL - Jersey County, IL	3
	1 site - Hardin, IL - Calhoun County, IL	3
	1 site - Hillview, IL - Greene County, IL	3
	1 site - Menard Correctional Center - Randolph County, IL	3
	1 site - Valmeyer, IL - Monroe County, IL	3
Major Water Supply Intakes		
	1 site - Randolph County, IL	1
	1 site - Evansville, IL - Randolph County, IL	3
Water Well Fields		
	4 sites - St. Clair County, IL	1
	27 sites - Madison County, IL	1
	3 sites - Monroe County, IL	1
	1 site - Randolph County, IL	1
	5 sites - Union County, IL	1
	3 sites - Jackson County, IL	1
	1 site - Alexander County, IL	1
Sewage Treatment Plants		
Power Plants		
	1 coal-fired Union Electric, Portage des Sioux, MO	
	1 coal-fired Union Electric, Venice, IL	
	1 coal-fired Union Electric, Rush Island, MO	
Hospitals		
	1 - St. Clair County, IL	1
Group Homes		
Schools		
	53 - St. Clair County, IL	1
	57 - Madison County, IL	1
	2 - Monroe County, IL	1
	1 - Randolph County, IL	1

ST. LOUIS DISTRICT

	7 - Union County, IL	1
	4 - Jackson County, IL	1
	4 - Alexander County, IL	1
Federal and State Bridges		
Prisons		
	1 - Menard Correctional Facility Chester, IL	1
	1 - St. Louis County Medium Security Facility, Chesterfield, MO	6
Airports		
	1 - Perry County Airport, MO	1
	1 - Bi-State ST. Clair County, IL	1
	1 - Spirit of St. Louis Airport, Chesterfield, MO	6
Police and Fire Departments		
	Afton Fire Protection District	4
	Biehle Community Fire Protection District	4
	Cape Girardeau Fire Dept.	4
	Chesterfield Fire Protection District	4
	Clarksville Volunteer Fire Department	4
	Crystal City Fire Protection District	4
	East County Fire Prot. District - Cape Girardeau, MO	4
	Elsberry Volunteer Fire Department	4
	Festus City and Rural Fire Department	4
	Herculaneum Fire Department	4
	Jefferson R-7 Fire Prot. District - Festus, MO	4
	Lemay Fire Protection District	4
	Lincoln County Fire Prot. District No. 1 - Troy, MO	4
	Lincoln Fire Department	4
	Louisiana Fire Department	4
	Mallinckrodt - St. Louis, MO	4
	Old Monroe Community Volunteer Fire Department	4
	Perry County Rural Fire Protection District	4
	Portage des Sioux Community Volunteer Fire Department	4
	Springdale Fire Protection District - Fenton, MO	4
	Ste. Genevieve Volunteer Fire Department	4
	Troy Rural Fire Department	4
	Valley Park Fire Protection District	4

Dataset Description

ST. LOUIS DISTRICT Critical Facilities	Coverage	Format	Locational Info.	Accuracy (FEET)	Source Date	Source
Municipal & Industrial NPDES						
Superfund Sites						
Landfills						
Hazardous Waste Facilities	1 1	1 3	GIS 3	N/A N/A	? ?	1 5
PetroChemical & Major Pipeline	1 1	3 3	4 3	N/A N/A	? ?	2 6
Water Treatment Plants	1	3	3	N/A	?	3
Major Water Supply Intakes	1	1	GIS	N/A	?	1
Water Well Fields	1	1	GIS	N/A	?	1
Sewage Treatment Plants						
Power Plants						
Hospitals	1	1	GIS	N/A	?	1
Group Homes						
Schools	1	1	GIS	N/A	?	1
Federal and State Bridges						
Prisons	1 1	1 3	GIS 3	N/A N/A	? ?	1 6
Airports	1 1	1 3	GIS 3	N/A N/A	? ?	1 6
Police and Fire Departments	1	3	2	N/A	?	4

Coverage	Format	Locational Information (if non-GIS)
1. - FPMA Study Area Floodplain 2. - 1993 Flood Zone 3. - Only Portions of study area	1 - Digital Spatial (GIS) 2 - Digital Non-spatial (Spreadsheet) 3 - Paper	1 - SECT/WN/RANGE 2 - STREET ADDRESS 3 - City/County 4 - River Mile

SOURCES:
1 - Rock Island Critical Facilities GIS Mapping.
2 - St. Louis District Corps of Engineers, River Mileage Guide.
3 - The 1993 Flood Mississippi River in Illinois - Long Term Resource Monitoring Program.
4 - Missouri Division of Fire Safety.
5 - State of Missouri Division of Natural Resources.
6 - St. Louis District Corps of Engineers files.

ATTACHMENT 5

EVALUATION TABLES OF ACTION ALTERNATIVES (WITH CELL NOTES)

Enclosed are the matrix tables used for evaluation of the action alternatives, as discussed in Chapter 9. Three of the districts have provided notes supporting entries in each of the cells. Further supporting data is provided in Appendix B. Each district's evaluation begins on the following pages:

Omaha District	**page ATT 5-2**
Kansas City District	**page ATT 5-12**
St. Paul District	**page ATT 5-13**
Rock Island District	**page ATT 5-21**
St. Louis District	**page ATT 5-22**

Table 5–1. Base Conditions for FPMA study area.

		A	B	C	D	E	F	G	H	I	J
	IMPACT CATEGORIES	Base Cond. [All Disast. Counties]	Base Cond. [FPMA Imp. Counties]	National Flood Ins. Program Regs.	State Fldpln. Mgm & Zoning	Local Fldpln. Mg & Zoning	Relocation, Mitigation Programs	Disaster Relief Programs	Floodplain Wetland Restor. Pro	Agricultura Support Policies	Signif. Findings
	ECONOMIC ($000's)		[1]								
	Flood Damages										
1	Residential (Urban)	$760,892	$662,008								
2	Other (Urban)	$1,612,543	$1,447,322								
3	Agricultural	$3,852,701	$817,054								
4	Other Rural	$233,648	$161,010								
	Chg. in Govt. Expend.										
5	Emergen. Resp. Costs	$227,405	$200,663								
6	Disaster Relief (Agric.)	$1,160,632	$285,180								
7	Disaster Relief (Human R.)	$1,297,474	$551,862								
8	Flood Insurance (NFIP)	$371,969	$276,496								
9	Flood Insurance (FCIC)	$748,095	$269,061								
	Chg. Value of FP Resources										
10	Net Ag RE Values	–	–								
11	Net Urban RE Values	–	–								
	ENVIRONMENTAL										
	Natur. Resour. (# acres)										
12	Non–Forested Wetl. (acres)	–	365,285								
13	Threat. & Endang. (# / Occ.)	–	(281/1,043)								
14	Forest (acres)	–	534,705								
	Natural Fldpln. Functions										
15	Fldpln. inundated (acres)	–	2,685,281								
	Cultural										
16	Archeol Impacts (–5 to +5)	–	–1								
16A	Hist. Sites (–5 to +5)		–1								
	Open Space										
17	Public lands (acres)	–	392,512								
18	Recreation sites (#)	–	485								
	REDUCT. OF RISK										
	Critical Facilities										
19	# Facil. w/harmful releases	–	207								
20	# other critical facilities	–	1,208								
	Prot./Avoid. of Harm										
21	# people vulnerable	185,630	134,849								
	Social Well Being										
22	# communities vulnerable	433	293								
23	# resident. struct. vulnerable	56,339	42,743								
	IMPLEMENT. COSTS										
24	Structural Costs	–	–								
25	Other Costs	–	–								

[1] Economic impacts collected only at the county level

OMAHA DISTRICT ANALYSIS

CELL L1: Residential (Urban). Increases damages to rural communities which were not flooded in the baseline.

CELL L2: Other (Urban). Increases damages to rural communities which were not flooded in the baseline.

CELL L3: Agricultural. Increase in damages due to increases in overbank flooded area.

CELL L4: Other Rural. Increase in damages due to increases in overbank flooded area.

CELL L5: Emergency Response Costs. Change in costs are related to the percent change in the residential (Urban) damages.

CELL L6: Disaster Relief (Agricultural). Change in costs are related to the percent change in the agricultural damages.

CELL L7: Disaster Relief (Human Related). Change in costs are related to the percent change in the residential (Urban) damages.

CELL L8: Flood Insurance (NFIP). Change in costs are related to the percent change in the residential (Urban) damages.

CELL L9: Flood Insurance (FCIC). Change in costs are related to the percent change in the agricultural damages.

CELL L10: Net Agricultural Product. Could decrease the value of land which would no longer be protected by as much as 30- to 40-percent.

CELL L11: Net Urban Real Estate Values. Could decrease the value land which would no longer be protected.

Cell L12: Based on the assumption that 10% of land would revert to natural conditions if levees were removed and of that 10%, 6% would revert to wetlands. Ratio derived from ERI.

Cell L13: Based on the assumption that with increased habitat resulting from land use change, the number of threatened/endangered numbers and occurrences would increase.

Cell L14: Based on the assumption that 10% of land would revert to natural conditions if levees were removed and of that 10%, 1% would revert to riparian woodlands.

Cell L16: Removing the levees would cause damages to sites currently buried under existing levees. In addition, the spoil piles would have to be placed somewhere, possibly causing additional damage to currently unknown sites. This alternative was given a -2.

Cell L17-18: Based on the assumption that agricultural land left unprotected because of levee removal would have to be purchased by the Federal government.

CELL L19: Number of facilities with harmful releases. Could increase the number of facilities with harmful releases which would be vulnerable to flooding.

CELL L20: Number of other critical facilities. Could increase the number of other critical facilities which would be vulnerable to flooding.

CELL L21: Number of people vulnerable. Could increase the number of people which would be vulnerable to flooding.

CELL L22: Number of communities vulnerable. Could increase the number of communities which would be vulnerable to flooding.

CELL L23: Number of residential structures vulnerable. Could increase the number of residential structures which would be vulnerable to flooding.

CELL L24 LOW: Partial removal of levee.
HIGH: Total removal of levee.

CELL M1: Residential (Urban). Increases damages to rural communities which were not flooded in the baseline.

CELL M2: Other (Urban). Increases damages to rural communities which were not flooded in the baseline.

CELL M3: Agricultural. Increase in damages due to increases in overbank flooded area.

CELL M4: Other Rural. Increase in damages due to increases in overbank flooded area.

CELL M5: Emergency Response Costs. Change in costs are related to the percent change in the residential (Urban) damages.

CELL M6: Disaster Relief (Agricultural). Change in costs are related to the percent change in the agricultural damages.

CELL M7: Disaster Relief (Human Related). Change in costs are related to the percent change in the residential (Urban) damages.

CELL M8: Flood Insurance (NFIP). Change in costs are related to the percent change in the residential (Urban) damages.

CELL M9: Flood Insurance (FCIC). Change in costs are related to the percent change in the agricultural damages.

CELL M10: Net Agricultural Product. Could decrease the value of land which would no longer be behind the levee by as much as 60- to 70-percent.

CELL M11: Net Urban Real Estate Values. No change in value.

Cell M12: Based on the assumption that 10% of land would revert to natural conditions if levees were removed and of that 10%, 6% would revert to wetlands. Ratio derived from ERI.

Cell M13: Based on the assumption that with increased habitat resulting from land use change, the number of threatened/endangered numbers and occurrences would increase.

Cell M14: Based on the assumption that 10% of land would revert to natural conditions if levees were removed and of that 10%, 1% would revert to riparian woodlands.

Cell M16: The Set Back alternative received a -1. Certain historic structures would be protected while others would be placed on the wet side of the new levee alignment. A number of archeological sites would likely be impacted during costruction and borrow activities.

Cell M17-18: Based on the assumption that agricultural land left unprotected because of levee removal would have to be purchased by the Federal government.

CELL M19: Number of facilities with harmful releases. Could decrease the number of facilities with harmful releases which would be vulnerable to flooding.

CELL M20: Number of other critical facilities. Could decrease the number of other critical facilities which would be vulnerable to flooding.

CELL M21: Number of people vulnerable. Could decrease the number of people which would be vulnerable to flooding.

CELL M22: Number of communities vulnerable. Could decrease the number of communities which would be vulnerable to flooding.

CELL M23: Number of residential structures vulnerable. Could decrease the number of residential structures which would be vulnerable to flooding.

CELL M24: LOW: Partial removal of original levee.
HIGH: Total removal of the original levee.

CELL N1: Residential (Urban). Increases damages to rural communities which were not flooded in the baseline.

CELL N2: Other (Urban). Decreases damages to because of stage decreases on other (urban) structures.

CELL N3: Agricultural. Increase in damages due to increases in overbank flooded area.

CELL N4: Other Rural. Increase in damages due to increases in overbank flooded area.

CELL N5: Emergency Response Costs. Change in costs are related to the percent change in the residential (Urban) damages.

CELL N6: Disaster Relief (Agricultural). Change in costs are related to the percent change in the agricultural damages.

CELL N7: Disaster Relief (Human Related). Change in costs are related to the percent change in the residential (Urban) damages.

CELL N8: Flood Insurance (NFIP). Change in costs are related to the percent change in the residential (Urban) damages.

CELL N9: Flood Insurance (FCIC). Change in costs are related to the percent change in the agricultural damages.

CELL N10: Net Agricultural Product. Could decrease the value of land which would no longer be protected by as much as 5- to 10-percent.

CELL N11: Net Urban Real Estate Values. Could decrease the value of land which would no longer be protected.

Cell N12-14: Negligible change from existing conditions.

Cell N16: The 25 year levee alternative received a -1 for much the same reasons as the Set Back alternative. With a lower elevation for flood protection, both historic sites and archeological sites will be impacted to a certain extent by upcoming floods.

Cell N17-18: Negligible change from existing conditions.

CELL N19: Number of facilities with harmful releases. Could increase the number of facilities with harmful releases which would be vulnerable to flooding.

CELL N20: Number of other critical facilities. Could increase the number of other critical facilities which would be vulnerable to flooding.

CELL N21: Number of people vulnerable. Could increase the number of people which would be vulnerable to flooding.

CELL N22: Number of communities vulnerable. Could increase the number of communities which would be vulnerable to flooding.

CELL N23: Number of residential structures vulnerable. Could increase the number of residential structures which would be vulnerable to flooding.

CELL N24 LOW: 25-year Erodible Plugs.
HIGH: Same.

CELL 01: Residential (Urban). Decreases damages to rural communities behind the levees but increases damages in the unleveed portions of the system.

CELL 02: Other (Urban). Decreases damages to rural communities behind the levees but increases damages in the unleveed portions of the system.

CELL 03: Agricultural. Decrease in damages due to decreases in overbank flooded area.

CELL 04: Other Rural. Decrease in damages due to decreases in overbank flooded area.

CELL 05: Emergency Response Costs. Change in costs are related to the percent change in the residential (Urban) damages.

CELL 06: Disaster Relief (Agricultural). Change in costs are related to the percent change in the agricultural damages.

CELL 07: Disaster Relief (Human Related). Change in costs are related to the percent change in the residential (Urban) damages.

CELL 08: Flood Insurance (NFIP). Change in costs are related to the percent change in the residential (Urban) damages.

CELL 09: Flood Insurance (FCIC). Change in costs are related to the percent change in the agricultural damages.

CELL 010: Net Agricultural Product. Could increase the value of land which would gain protection by as much as 5- to 10-percent.

CELL 011: Net Urban Real Estate Values. No change in value.

Cell 012-14: Negligible change from existing conditions.

Cell 016: The Fully Confine alternative also received a -1 score. By fully confining the flood, there is the possibility that the scouring action within the channel will unearth as yet undiscovered sites contained within alluvial fans. These sites tend to be significant due to their great age and would otherwise be intact below the channel.

Cell 017-18: Negligible increase in the amount of Federally owned land due to increased levee footprint and right of way; however, this does not constitute an increase in recreational opportunities.

CELL 019: Number of facilities with harmful releases. Could decrease the number of facilities with harmful releases which would be vulnerable to flooding.

CELL O20: Number of other critical facilities. Could decrease the number of other critical facilities which would be vulnerable to flooding.

CELL O21: Number of people vulnerable. Could decrease the number of people which would be vulnerable to flooding.

CELL O22: Number of communities vulnerable. Could decrease the number of communities which would be vulnerable to flooding.

CELL O23: Number of residential structures vulnerable. Could decrease the number of residential structures which would be vulnerable to flooding.

CELL O24 LOW: No overtopping. Includes some new levee placement.
HIGH: Same.

CELL S1: Residential (Urban). Increases damages to rural communities which were not flooded in the baseline.

CELL S2: Other (Urban). Increases damages to rural communities which were not flooded in the baseline.

CELL S3: Agricultural. Increase in damages due to increases in overbank flooded area.

CELL S4: Other Rural. Increase in damages due to increases in overbank flooded area.

CELL S5: Emergency Response Costs. Change in costs are related to the percent change in the residential (Urban) damages.

CELL S6: Disaster Relief (Agricultural). Change in costs are related to the percent change in the agricultural damages.

CELL S7: Disaster Relief (Human Related). Change in costs are related to the percent change in the residential (Urban) damages.

CELL S8: Flood Insurance (NFIP). Change in costs are related to the percent change in the residential (Urban) damages.

CELL S9: Flood Insurance (FCIC). Change in costs are related to the percent change in the agricultural damages.

CELL S10: Net Agricultural Product. Could decrease the value of land which would no longer be protected by as much as 30- to 40-percent.

CELL S11: Net Urban Real Estate Values. Could decrease the value land which would no longer be protected.

Cell S12: There would be an increase in the number of acres of wetlands based on the assumption that more frequent flooding would occur and river bed degradation below Gavins Point Dam would decrease and allow for the maintenance of a hydraulic connection between wetlands and the river.

Cell S13: Negligible change from existing conditions, because some species, such as the bald eagle, benefit from the permanent open water below the dams.

Cell S14: There would be an increase in the number of acres of woodlands because thousands of acres of bottomland forest were inundated by the reservoirs and marginal farmland would be allowed to revert to natural conditions.

Cell S16: The No Reservoir alternative was given a -1 score. Although unhampered flows would damage some sites, especially historic structures, the layering of alluvial material over exposed sites would cause some archeological sites to be protected.

Cell S17-18: There would be a decrease in the number of Federally owned lands and recreational opportunities if the reservoirs were removed.

CELL S19: Number of facilities with harmful releases. Could increase the number of facilities with harmful releases which would be vulnerable to flooding.

CELL S20: Number of other critical facilities. Could increase the number of other critical facilities which would be vulnerable to flooding.

CELL S21: Number of people vulnerable. Could increase the number of people which would be vulnerable to flooding.

CELL S22: Number of communities vulnerable. Could increase the number of communities which would be vulnerable to flooding.

CELL S23: Number of residential structures vulnerable. Could increase the number of residential structures which would be vulnerable to flooding.

CELL V1: Residential (Urban). Decreases damages in all areas of the flood control system.

CELL V2: Other (Urban). Decreases damages to rural communities behind the levees.

CELL V3: Agricultural. Decrease in damages due to decreases in overbank flooded area.

CELL V4: Other Rural. Decrease in damages due to decreases in overbank flooded area.

CELL V5: Emergency Response Costs. Change in costs are related to the percent change in the residential (Urban) damages.

CELL V6: Disaster Relief (Agricultural). Change in costs are related to the percent change in the agricultural damages.

CELL V7: Disaster Relief (Human Related). Change in costs are related to the percent change in the residential (Urban) damages.

CELL V8: Flood Insurance (NFIP). Change in costs are related to the percent change in the residential (Urban) damages.

CELL V9: Flood Insurance (FCIC). Change in costs are related to the percent change in the agricultural damages.

CELL V10: Net Agricultural Product. No change in value.

CELL V11: Net Urban Real Estate Values. Could increase the value of land.

Cell V12: Negligible change from existing conditions.

Cell V13: Positive impact based on increased acres and diversity of habitat.

Cell V14: Negligible change from existing conditions.

Cell V16: This alternative would reduce runoff by 5%. A score of -1 was given to this alternative because additional fill would be needed to construct small dams on the tributaries. These small dams would flood some significant prehistoric and historic archeological sites, besides impacting an unknown number of significant sites during the borrow operations.

Cell V17-18: The number of acres of Federally owned land would increase because of increased implementation of FSA/FACTA programs.

CELL V19: Number of facilities with harmful releases. Could decrease the number of facilities with harmful releases which would be vulnerable to flooding.

CELL V20: Number of other critical facilities. Could decrease the number of other critical facilities which would be vulnerable to flooding.

CELL V21: Number of people vulnerable. Could decrease the number of people which would be vulnerable to flooding.

CELL V22: Number of communities vulnerable. Could decrease the number of communities which would be vulnerable to flooding.

CELL V23: Number of residential structures vulnerable. Could decrease the number of residential structures which would be vulnerable to flooding.

CELL W1: Residential (Urban). Decreases damages in all areas of the flood control system.

CELL W2: Other (Urban). Decreases damages to rural communities behind the levees.

CELL W3: Agricultural. Decrease in damages due to decreases in overbank flooded area.

CELL W4: Other Rural. Increase in damages due to increases in overbank flooded area.

CELL W5: Emergency Response Costs. Change in costs are related to the percent change in the residential (Urban) damages.

CELL W6: Disaster Relief (Agricultural). Change in costs are related to the percent change in the agricultural damages.

CELL W7: Disaster Relief (Human Related). Change in costs are related to the percent change in the residential (Urban) damages.

CELL W8: Flood Insurance (NFIP). Change in costs are related to the percent change in the residential (Urban) damages.

CELL W9: Flood Insurance (FCIC). Change in costs are related to the percent change in the agricultural damages.

CELL W10: Net Agricultural Product. No change in value.

CELL W11: Net Urban Real Estate Values. Could increase the value of land.

Cell W16: This alternative was also given a -1, for the same reasons given for the Runoff Reduction 5% alternative.

CELL W19: Number of facilities with harmful releases. Could decrease the number of facilities with harmful releases which would be vulnerable to flooding.

CELL W20: Number of other critical facilities. Could decrease the number of other critical facilities which would be vulnerable to flooding.

CELL W21: Number of people vulnerable. Could decrease the number of people which would be vulnerable to flooding.

CELL W22: Number of communities vulnerable. Could decrease the number of communities which would be vulnerable to flooding.

CELL W23: Number of residential structures vulnerable. Could decrease the number of residential structures which would be vulnerable to flooding.

ACTION ALTERNATIVES
KANSAS CITY DISTRICT

		A	B	L	N	O	S
				ACTION ALTERNATIVES AFFECTING HYDRAULIC CONDITIONS			
				AGRICULTURAL LEVEES			UPLAND RETENTION/ WATERSHED MEASURES
	IMPACT CATEGORIES	Base Cond. [All Disast. Counties]	Base Cond. [Floodpln. Impacts]	Remove	Uniform Ht. [25-YR.]	Raise	Without Reservoirs
	ECONOMIC (1,000 $'s)		[1]				
	Flood Damages						
1	Residential (Urban)	$102,326	$72,556	-7%	-4%	-50%	7%
2	Other (Urban)	$650,251	$541,462	-10%	-5%	-(75-90)%	500%
3	Agricultural	$1,373,434	$303,322	+(0-2)%	-20%	-80%	Insignificant
4	Other Rural	$118,447	$75,509	+(0-2)%	-20%	-80%	Insignificant
	Chg. in Govt.Expend.						
5	Emergen.Resp.Costs	$19,423	$16,332	-	-	-	+
6	Disaster Relief (Agric.)	$210,198	$64,762	NC	-low	-high	Insignificant
7	Disaster Relief (Human R.)	$285,853	$166,510	-low	-low	-high	+high
8	Flood Insurance (NFIP)	$100,779	$46,687	Insignificant	-NC to low	-	+
9	Flood Insurance (FCIC)	$185,389	$92,975	+	-NC to low	-high	+low
	Chg.Value of FP Resources						
10	Net Ag RE Values	-	-	-20%	4%	30%	-10%
11	Net Urban RE Values	-	-	-20%	Insignificant	-	-30%
	ENVIRONMENTAL						
	Natur.Resour.(# acres)						
12	Non-Forested Wetl. (acres)	-	42,700	+5,600	NC	NC	NC
13	Threat.&Endang. (# / Occ.)	-	30/80	+	-	-	NC
14	Forest (acres)	-	58,200	+7,100	NC	NC	NC
	Natural Fldpln.Functions						
15	Fldpln.inundated (acres)	-	100%	NC	NC	-90%	NC
	Cultural						
16	Archeol Impacts (-5 to +5)	-		-1 (-1)	-3 (-1)	-3 (-1)	0 (-1)
16A	Hist.Sites(-5 to +5)			-1 (-1)	-1 (-1)	-1 (-1)	0 (-1)
	Open Space						
17	Public lands (acres)	-	43,100	NC	NC	NC	NC
18	Recreation sites (#)	-	20	NC	NC	NC	NC
	REDUCT.OF RISK						
	Critical Facilities						
19	# Facil. w/harmful releases	-	27	NC	Insignificant	-NC/low	+
20	# other critical facilities	-	76	NC	Insignificant	-low/mod	+
	Prot./Avoid. of Harm						
21	# people vulnerable	28,375	21022	-low	-low	-mod/high	+mod/high
	Social Well Being						
22	# communities vulnerable	229	141	-2%	-3%	-(20-70)%	+
23	# resident.struct.vulnerable	8711	6287	-7%	-5%	-53%	+
	IMPLEMENT. COSTS						
24	Structural Costs	-	-	+$16.4 MIL +LERRD	+$340 MIL +LERRD	+$2.5 BIL +LERRD	?????
25	Other Costs	-	-	High	Low	Moderate	High

[1] Economic impacts collected only at the county level

ACTION ALTERNATIVES
St. Paul District

		A	B	B'	B"	P	S	V	W
	IMPACT CATEGORIES	Base Cond. [All NCS]	Base Cond. [Floodpln-NCS]	Base Cond. Pools7-10 MS Riv.	Base Cond. MN Riv.	URBAN LEVEES [500-Yr.]	UPLAND RETENTION Without Reservoirs	Runoff Red. [Decr. 5%]	Runoff Red. [Decr. 10%]
						(1)	(2)	(3)	(3)
	ECONOMIC ($000's)								
	Fld.Dam.								
1	Residential (Urban)	$21,460	$5,428			0	0	0	0
2	Other (Urban)	$39,466	$25,918			0	0	0	0
3	Agricultural	$484,674	$95,155			0	0	-200,000	-400,000
4	Other Rural	$6,868	$2,599			0	0	-2,875	-5,750
	Chg. in Govt.Expend.								
5	Emergen.Resp.Costs	$10,226	$4,193			0	0	0	0
6	Disaster Relief (Agric.)	$283,614	$52,295			0	0	-118,750	-237,500
7	Disaster Relief (Human R.)	$254,508	$60,359			0	0	0	0
8	Flood Insurance (NFIP)	$2,237	$1,370			0	0	0	0
9	Flood Insurance (FCIC)	$215,668	$31,391			0	0	-87,500	-175,000
	Chg.Value of FP Resources								
10	Net Ag RE Values	-	-			0	0	HIGH	HIGH
11	Net Urban RE Values	-	-			+< 5%	0	0	0
	ENVIRONMENTAL								
	Natur.Resour.(# acres)								
12	Non-Forested Wetl. (acres)		74,805	21,000	2,230	-	0	0	0
13	Threat.&Endang. (# / Occ.)		75/406	54/243	6/7	-	-	+	+
14	Forest (acres)		76,095	39,000	4,530	0	0	0	0
	Natural Fldpln.Functions								
15	Fldpln.Inundated (acres)					0	-	-	-
	Cultural								
16	Archeol Impacts (-5 to +5)		-1	-1	-2	-2(0)	-2(0)	-1(-1)	-1(-1)
16A	Hist.Sites(-5 to +5)		-1						
	Open Space								
17	Public lands (acres)		77,000	47,000	2,214	0	0	0	0
18	Recreation sites (#)		127	46	8	0	0	0	0
	REDUCT.OF RISK								
	Critical Facilities								
19	# Facil. w/harmful releases		3			0	0	0	0
20	# other critical facilities		13			0	0	0	0
	Prot./Avoid. of Harm								
21	# people vulnerable	11,677	5,700			0	0	0	0
	Social Well Being								
22	# communities vulnerable	64	16			0	0	0	0
23	# resident.struct.vulnerable	2,246	1,371			0	0	0	0
	IMPLEMENT. COSTS								
24	Structural Costs	-	-			+2,770	-	0	0
25	Other Costs	-	-			-	-	+1,250,000	+2,500,000

(1) Changes in impacts relative to column B"
(2) Changes in impacts relative to column B'
(3) Changes in impacts relative to column A (economics) and column B (environmental)

File:ACTNCS1

ST. PAUL DISTRICT ANALYSIS

Cell P1: No change in impact. Benefit would not be realized until a less than .006 annual probability flood event on the Minnesota River along this reach occurs. This is the estimate of the level of protection (170 year) currently available at Henderson. Mankato is now estimated to have a 500 year (.002 annual flood probability) level of protection.
Cell P2: No change in impact.
Cell P3: No change in impact.
Cell P4: No change in impact.
Cell P5: No measurable change in impact. It is possible that with this increased level of protection there might have been fewer "anticipatory" costs incurred related to emergency flood response.
Cell P6: No change in impact.
Cell P7: No change in impact.
Cell P8: No change in impact.
Cell P9: No change in impact.
Cell P10: No change in impact.
Cell P11: There is the potential for a very slight increase in property values and assessments related to the increased flood protection; this effect is likely very small at these locations.

Cell P12: no significant change
Cell P13: no significant change
Cell P14: no significant change
Cell P15: no change for 1993 flood. Providing 500-year protection to urban areas would not have changed acres of urban areas protected/unprotected by the flood of 1993. For higher frequency floods the percent floodplain inundated would decrease.
Cell P16: The only city this would apply to is Henderson, Minnesota. To determine the effect of raising and extending the levee (both width and length) would require a survey.
Cell P16A: As no historic sites in Henderson suffered from the flooding, having a higher levee would not have changed the number of sites affected.
Cell P17: no change expect for small right-of-way parcels.
Cell P18: no change

Cell P19: No change in impact. For very extreme flood events, the added flood protection would offer increased protection of critical facilities.

Cell P20: No change in impact. For very extreme flood events, the added flood protection would offer increased protection of critical facilities.
Cell P21: No change in impact. Transportation disruptions in the form of road and bridge closures would continue even with the increased level of protection.
Cell P22: No change in impact. "
Cell P23: No change in impact. For very extreme flood events, the added flood protection would decrease exposure of residential structures.

Cell P24: Engineering costs to increase levee heights at Henderson are roughly estimated to be $ 2,270,000.
Cell P25: No costs estimated.

Other Environmental Impacts: Increasing urban levee heights at Henderson would result in a slight encroachment into the floodplain and result in the loss of a small acreage of floodplain forest. These losses would not be significant on a systemic basis. Construction activities could result in localized short term minor effects on air quality, noise and water quality.

Cell S1: No change in impact for the area along the Minnesota River being examined in the FPMA, downstream of Mankato, or below the confluence of the Minnesota with the Mississippi River.
Cell S2: No change in impact.
Cell S3: No change in impact. For smaller events, there would be some negative impact, especially in upstream areas along the Minnesota River not being covered in the FPMA, if the Big Stone Lake and Lac Qui Parle reservoirs were not in place.
Cell S4: No change in impact. "
Cell S5: No change in impact. "
Cell S6: No change in impact. "
Cell S7: No change in impact.
Cell S8: No change in impact.
Cell S9: No change in impact. See comment for S3.
Cell S10: No change in impact. See comment for S3.
Cell S11: No change in impact.

Cell S12: no change
Cell S13: no change
Cell S14: no change
Cell S15: Slight increase but this is not quantifiable at the level of detail of existing floodplain elevation data.

Cell S16: Without the Lac Qui Parle reservoir, Fort Renville and archeological sites around the reservoir would not have suffered the adverse effects of the pool being so high for so long. In the study reach between Mankato and Henderson, the reduction in the flood height would have been negligible, and therefore the effect on archeological and historic sites of the flood would not have changed.

Cell S16A: no change
Cell S17: no change
Cell S18: no change

Cell S19: No change in impact.
Cell S20: No change in impact.
Cell S21: No change in impact. See comment for S3.
Cell S22: No change in impact. See comment for S3.
Cell S23: No change in impact.

Cell S24: Cost of "removing" reservoirs not estimated.
Cell S25: Other costs, if any, not determined.

Other Impacts: In the long term the "no reservoir" alternative would likely result in changes in land use in the floodplain of the Minnesota River because of increased frequency of flooding. In annually flooded zones this would likely cause agricultural land to revert to a natural condition. Farming would continue in other areas depending on various Department of Agriculture incentive/price support/disaster payment programs. Lac Qui Parle and Marsh Lakes are significant waterfowl staging areas during the fall migration. Lac Qui Parle Lake is also an important regional fishery and recreation area. Removal of the dams would significantly alter the current nature and use of those areas.

Cell V1: No measurable change in impact.

Cell V2: No measurable change in impact.

Cell V3: An estimate of crop damages per acre, based on total crop losses divided by affected acres, is approximately $160/acre. If it is assumed that these damages would have been avoided if converted acreage to wetlands had previously taken place, a reduction in damages of $200 million (using 1.25 mil. acres) might have been realized. NOTE: Cells V6 and V9, ag disaster relief and crop insurance, presumably cover much of this damage. These numbers are therefore NOT additive with the entry in this cell.

Cell V4: An estimate of damages associated with land restoration, ditch restoration, and farm structure losses is roughly $2.30/acre, assuming all three million acres were equally impacted. Total damages in this impact category were estimated at $6.9 million in St. Paul District. If 1.25 mil. acres had previously been converted, then approximately $2,875,000 in damages might have been avoided. It is assumed that these damages were among the losses covered by expenditures in the ag disaster relief impact category (Cell V6), so these numbers are NOT additive.

Cell V5: No measurable change in impact for the 1993 flood event. For future, larger events in St. Paul District, there could be a small reduction in emergency response costs along the major rivers with this alternative in place.

Cell V6: Disaster relief is estimated at roughly $95/acre ($284 million in ag disaster expenditures for declared disaster counties in St. Paul District divided by an estimated three million affected acres using FCIC records). If these expenditures are assumed to be no longer required on converted acreage (1.25 mil. acres in this case), a reduction in cost of $118,750,000 would be expected.

Cell V7: No measurable change in impact for the 1993 flood event. For future, larger events in St. Paul District, there could be a small reduction in human resources related disaster relief costs with this alternative in place.

Cell V8: No measurable change in impact.

Cell V9: Based on FCIC payments, an estimate of $70/acre was paid. If it is assumed that this payment would no longer be made on converted acreage, an estimate of the reduced expenditures would be $87.5 million for 1,250,000 acres.

Cell V10: The change in land use in obtaining permanent conservation easements would lead to reduced property values and decreased property tax receipts.

The extent of this reduction, given the very large number of acres being identified and the large number of jurisdictions that presumably would be affected, has not been quantitatively estimated.

Cell V11: No change in impact.

Cell V12: No change in floodplain acreage. Significant changes in wetland acreage in the upland portions of the watershed would occur with this alternative. Based on an assumptions outlined above, a 5% reduction in runoff would require that 1.25 million acres of wetland be restored.

Cell V13: Beneficial impacts to migratory T&E species might be seen from this alternative because of improved habitat conditions along migratory routes. Increased upland wetlands could provide increased corridors for migratory species that use floodplains for part of their life requirements.

Cell V14: no change

Cell V15: Slight Decrease. A change in flood stage for the 1993 event of approximately 6 inches was calculated by the hydraulic/hydrology work group. This would result in a decrease in extent of floodplain inundated but this is not quantifiable at the level of detail of existing floodplain elevation data.

Cell V16: Slight decrease. Reducing the runoff by 5 per cent would benefit archeological sites by lowering the flood height by 6 inches. It is unknown how many sites would benefit, however, and some would still suffer from erosion. In general, decreasing upland run-off would limit the number of sites affected by flooding, especially for more frequent minor events.

Cell V16A: Reducing the runoff by 5 per cent would benefit both historic sites by lowering the flood height by 6 inches. Historic sites at Prairie du Chien that suffered water damage would have had less, but still some, water in their basements. Thus the effect of a flood equal to 1993 would still be a -1 rating. In general, decreasing upland run-off would limit the number of sites affected by flooding, especially for more frequent minor events.

Cell V17: no change

Cell V18: no change

Cell V19: No measurable change in impact.

Cell V20: No measurable change in impact.

Cell V21: No measurable change in impact for the 1993 flood. There could be a small reduction in the number of people vulnerable to flooding along the major rivers with this alternative in place.

Cell V22: No measurable change in impact.

Cell V23: No measurable change in impact.

Cell V24: Land treatment costs are one approach; cost estimate not developed.

Cell V25: Acquiring permanent conservation easements on 1,250,000 acres, at $1,000/acre, results in an estimate of $1,250,000,000.

Other Impacts: Generally, upland retention land treatment measures such as wetland restoration would have no adverse effects on cultural resources and could benefit them by reducing farming impacts. Some activities which may require extensive grading or excavation (such as terracing or construction of small retention reservoirs) could destroy or inundate archeological sites. Therefore, the potential effect for implementing this alternative was rated as -1 for archeological sites.

Water quality could be significantly improved to due to the decreased amount of sediment and agricultural chemicals being transported to the river. Wetland restoration and land treatment would result in a substantial increase in wildlife habitat. Waterfowl and other wetland/grassland dependant species would directly benefit from these actions. On a regional basis, restoration or improvement of these habitat types would increase habitat diversity and overall habitat quality for wildlife and would provide significant recreational benefits.

Cell W1: No measurable change in impact.
Cell W2: No measurable change in impact.
Cell W3: An estimate of crop damages per acre, based on total crop losses divided by affected acres, is approximately $160/acre. If it is assumed that these damages would have been avoided if converted acreage to wetlands had previously taken place, a reduction in damages of $400 million might have been realized, using 2.5 mil. acres. NOTE: Cells W6 and W9, ag disaster relief and crop insurance, presumably cover much of this damage. These numbers are therefore NOT additive with the entry in this cell.
Cell W4: An estimate of damages associated with land restoration, ditch restoration, and farm structure losses is roughly $2.30/acre, assuming all three million acres were equally impacted. Total damages in this impact category were estimated at $6.9 million in St. Paul District. If 2,500,000 acres had previously been converted, then approximately $5,750,000 in damages might have been avoided. It is assumed that these damages were among the losses covered by expenditures in the ag disaster relief impact category (Cell W6), so these numbers are NOT additive.

Cell W5: No measurable change in impact for the 1993 flood event. For future, larger events in the St. Paul District, there could be a small reduction in emergency response costs along major rivers with this alternative in place.

Cell W6: Disaster relief is estimated at roughly $95/acre ($284 million in ag disaster expenditures for declared disaster counties in St. Paul District divided by an estimated three million affected acres using FCIC records). If these expenditures are assumed to be no longer required on converted acreage (2.5 milion acres in this case), a reduction in cost of $237,500,000 would be expected.

Cell W7: No measurable change in impact for the 1993 flood event. For future, larger events in the St. Paul District, there could be a small reduction in human resources related disaster relief costs with this alternative in place.

Cell W8: No measurable change in impact.

Cell W9: Based on FCIC payments, an estimate of $70/acre was paid. If it is assumed that these costs would no longer be required on converted acreage, an estimate of reduced expenditures would be $175 million, assuming 2,500,000 converted acres.

Cell W10: The change in land use in obtaining permanent conservation easements would lead to reduced property values and decreased property tax receipts. The extent of this reduction, given the very large number of acres being identified and the large number of jurisdictions that presumably would be affected, has not been quantitatively estimated.

Cell W11: No change in impact.

Cell W12: No change in floodplain acreage. Significant changes in wetland acreage in the upland portions of the watershed would occur with this alternative. Based on an assumptions outlined above, a 5% reduction in runoff would require that 2.5 million acres of wetland be restored.

Cell W13: Beneficial impacts to migratory T&E species might be seen from this alternative because of improved habitat conditions along migratory routes. Increased upland wetlands could provide increased corridors for migratory species that use floodplains for part of their life requirements.

Cell W14: no change

Cell W15: Slight Decrease. A change in flood stage for the 1993 event of approximately 12 inches was calculated by the hydraulic/hydrology work group. This would result in a decrease in extent of floodplain inundated but this is not quantifiable at the level of detail of existing floodplain elevation data.

Cell W16: Slight decrease. Reducing the runoff by 10 per cent would benefit archeological sites as this would lower the flood height by 12 inches. It is not known how many archeological sites would benefit, however, and some would still suffer from erosion. In general, decreasing upland run-off would limit the number of sites affected by flooding, especially for more frequent minor events.

Cell W16A: Reducing the runoff by 10 per cent would benefit both historic sites as this would lower the flood height by 12 inches. Those historic sites at Prairie du Chien that suffered water damage would have had less, but still some, water in their basements. Thus the effect of a flood equal to 1993 would still be a -1 rating. In general, decreasing upland run-off would limit the number of sites affected by flooding, especially for more frequent minor events.

Cell W17: no change
Cell W18: no change

Cell W19: No change in impact.
Cell W20: No change in impact.

Cell W21: No measurable change in impact for the 1993 flood. There could be a small reduction in the number of people vulnerable to major flooding along the major rivers with this alternative in place.
Cell W22: No measurable change in impact.
Cell W23: No measurable change in impact.

Cell W24: Land treatment costs are one approach; cost estimate not developed.
Cell W25: Acquiring permanent conservation easements on 2,500,000 acres, at $1,000/acre, results in an estimate of $2,500,000,000.

Other Impacts: Generally, upland retention land treatment measures and wetland restoration would have no adverse effects on cultural resources and could benefit them by reducing farming impacts. Some activities which may require extensive grading or excavation (such as terracing or construction of small retention reservoirs) could destroy or inundate archeological sites. Therefore, the potential effect for implementing this alternative was rated as -1 for archeological sites.

Water quality could be significantly improved to due to the decreased amount of sediment and agricultural chemicals being transported to the river. Wetland restoration and land treatment would result in a substantial increase in wildlife habitat. Waterfowl and other wetland/grassland dependant species would directly benefit from these actions. On a regional basis, restoration or improvement of these habitat types would increase habitat diversity and overall habitat quality for wildlife and would provide considerable recreational benefits.

ACTION ALTERNATIVES
Rock Island District

																5/9/95
	ROCK ISLAND DISTRICT			ACTION ALTERNATIVES AFFECTING HYDRAULIC CONDITIONS												
		A	B	K	L	L1	L2	M	N	O	P	Q	R	S	T	U
		BASE CONDITIONS		AGRICULTURAL LEVEES							URBAN	CRITICAL FACILITIES		UPLAND RETENTION		
	IMPACT CATEGORIES	NCR Disaster Counties	NCR FPMA Counties	Limited Flood Fighting	Remove	Remove (n=0.08)	Remove (n = 0.32)	Set Back	25-Year Maximum Height	Raise to Contain '93 Flood	500-year Urban Levees	500-Year Priority Crit. Fac.	500-Year All Critical Facilities	Without reservoirs	Added reservoirs	Revised reservoir operation
				POTENTIAL FOR REDUCING FLOOD IMPACTS (1993 EVENT)												
	ECONOMIC															
	Flood Damage							Not								
1	Residential (Urban)	$203,000,000	$129,000,000	<-5%	-5-20%			Yet	<-5%	>-90%	>-90%	None	None	*	Minimal	None
2	Other (Urban)	$350,000,000	$262,000,000	<-5%	-5-20%			Modeled	<-5%	>-90%	>-90%	Moderate	Moderate	*	Minimal	None
3	Agricultural	$1,170,000,000	$140,000,000	<-5%	-10-50%				<-5%	>-50%	None	None	None	#	Minimal	None
4	Other Rural	$20,000,000	$9,000,000	<-5%	-10-20%				<-5%	>-50%	None	None	None	#	Minimal	None
	Change in Gov't Expend.															
5	Emerg. Response Costs	$128,000,000	$97,000,000	<-5%	-50%				<-5%	>-50%	>50%	Moderate	None	*	Minimal	None
	Disaster Relief															
6	Disaster Relief (Agric.)	$307,000,000	$72,000,000	<-5%	-10-50%				<-5%	>-50%	None	None	None	#	Minimal	None
7	Disaster Relief (Human Res.)	$366,000,000	$135,000,000	<-5%	-5-20%				<-5%	>-90%	>90%	Moderate	Moderate	*	Minimal	None
	Flood Insurance Payments															
8	NFIP	$113,000,000	$83,000,000	<-5%	-5-20%				<-5%	>-90%	>90%	None	None	*	Minimal	None
9	FCIC	$12,000.00	$7,000,000	<-5%	-10-50%				<-5%	>-50%	None	None	None	#	Minimal	None
	Change in Value of Floodplain Res.															
10	Net Ag Land Values			0	-30-40%			-60-70%	-5-10%	+5-10%	None	None	None	-low	Minimal	None
11	Net Urban RE Values			<+5%	+5-25%				<+5%	25%	+low	None	None	*	Minimal	None
	ENVIRONMENTAL															
	Natural Resources															
12	Non-Forested wetland (acres)		61,000	no chng		3,900	121,000	3,900	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
13	Threatened & Endangered (#)		68	61		61	61	61	61	61	7	7	7	7	7	7
13a	Threatened & Endangered (# occur.)		250	237		237	237	237	237	237	13	13	13	13	13	13
14	Forest (acres)		138,000	no chng		no chng	252,000	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
	Natural Floodplain Functions															
15	Floodplain Inundated (acres)			416,000		491,000	497,000		494,000	159,000	no chng	no chng	no chng	unavail	unavail	unavail
	Cultural Impacts (-5 to +5)															
16a	Historic Structures		-2	+4	-5			-3	-4	+4	+4	0	+1	-1	-1	-2
16b	Archeological Sites		-2	+4	+4			-3	-1	-2	-4	-4	-4	-1	-4	-2
	Open Space															
17	Public Lands (acres)		131,000	no chng		no chng	373,000	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
18	Recreation Sites (#)		202	no chng		no chng	300	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng	no chng
	REDUCTION OF RISK															
	Critical Facilities															
19	# Facilities w/harmful releases	151	134	@	@			@	@	@	@	@	@	@	@	@
20	# Other critical facilities	1,282	881	low	low-mod.				low	high	high	High	high	*	Minimal	None
	Protection/Avoidance of Harm															
21	# People vulnerable	70,000	44,000	low	low-mod.				low	high	high	None	None	*	Minimal	None
	Social Well Being															
22	# Communities vulnerable		78	low	low-mod.				low	>-90%	high	None	None	*	Minimal	None
23	# Residential Structures vulnerable	18,000	11,000	low	low-mod.				low	>-90%	high	None	None	*	Minimal	None
24	*Implementation Costs ($000's)*			5,800	829,000			248,000	3,200	290,000	25,000	Moderate	101,000		High	

NOTES:
1. @ No known releases in 1993 flood.
2. * Potential for huge increases to urban flood damages and impacts.
3. # *Potential for moderate increases to agricultural/rural impacts.*
4. Agricultural levee costs do not include LERRD
5. Urban levee is construction costs for West Des Moines

ACTION ALTERNATIVES
St. Louis District

		A	B	K	L	M	N	O	P	Q	R	S	T	U	V	W
					ACTION ALTERNATIVES AFFECTING HYDRAULIC CONDITIONS											
		Base Con	Base Cond.		AGRICULTURAL LEVEES				URBAN	CRITICAL FACILITIES		UPLAND RETENTION/WATERSHED MEASURES				
	IMPACT	[All Disast	[Floodpln.	Limited	Remove	MR&T	Uniform Ht.	Raise	LEVEES	[500-Yr.]	[500-Yr.]	Without	Added	Revised	Runoff Red.	Runoff Red.
	CATEGORIES	Counties]	Impacts]	Fld.Fighting	W\Crop	MRC	[25-YR.]		[500-Yr.]	[Priority]	[All]	Reservoirs	Reservoirs	Operation	[Decr. 5%]	[Decr. 10%]
	ECONOMIC ($000's)		[1]													
	Fld.Dam.															
1	Resid.(Urban) (millions)	NA	431.4	NA	-60.4	NA	26.1	-43.7	14.3	NA	NA	1,860.1	NA	NA	-0.7	-18.5
2	Other (Urban) (millions)	NA	549.3	NA	-78.5	NA	33.0	-55.2	0.0	NA	NA	2,388.5	NA	NA	-0.3	-27.9
3	Agricultural (millions)	NA	168.6	NA	8.8	NA	72.5	-126.4	0.0	NA	NA	101.2	NA	NA	-2.9	-13.3
4	Other Rural (millions)	NA	57.2	NA	3	NA	24.6	-42.9	0.0	NA	NA	5.5	NA	NA	-1.0	-15.0
	Chg. in Govt.Expend.															
5	Emerg.Resp.Costs(millions)	NA	101.8	NA	-14.3	NA	2.5	-13.8	0.0	NA	NA	439.6	NA	NA	-0.3	-7.6
6	Disast.Rel.(Agric.) (millions)	NA	36.4	NA	1.8	NA	0.9	-27.3	0.0	NA	NA	20.3	NA	NA	-0.4	-16.0
7	Disast.Rel.(Human R.)(mill)	NA	134.3	NA	2.9	NA	2.9	-13.3	0.0	NA	NA	575.9	NA	NA	-0.3	-6.3
8	Fld.Ins. (NFIP) (millions)	NA	133.7	NA	26.7	NA	8.1	-13.7	0.0	NA	NA	68.5	NA	NA	-0.7	-6.7
9	Fld.Ins. (FCIC) (millions)	NA	44.9	NA	19.3	NA	19.3	-33.7	0.0	NA	NA	26.9	NA	NA	-0.9	-3.8
	Chg.in Value of FP Res.															
10	Net Ag Product.	NA	NA	NA	-255.5	-73	73	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	Net Urban RE Values	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	ENVIRONMENTAL															
	Natur. Resour. (# acres)															
12	Non-Forested Wetlands	NA	154,990	NA	65,750	NA	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0
13	T & E Species	NA	35/96	NA	+	NA	0/0	0/0	0/0	0/0	0/0	0/0	NA	NA	0/0	0/0
14	Forest	NA	251,110	NA	74,150	NA	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0
	Natural Fldpln.Functions															
15	% of fldpln.inundated	NA	80	NA	15	-25	10	-62	0	0	0	19	NA	NA	0	0
15A	Cultural Archaeological	NA	-4	-4 (0)	-5 (-3)	-1 (-2)	-4 (-1)	-1 (-2)	-4 (-1)	-4 (-1)	-4 (-2)	-5 (+2)	-3 (-5)	-4 (-4)	-4 (-4)	-3 (-5)
16	# sites impacted Historical	NA	-3	-3 (0)	-2 (-1)	0 (-1)	-3 (0)	0 (-1)	0 (-1)	-2 (-1)	-1 (-2)	-4 (+1)	-3 (-4)	-3 (-3)	-3 (-3)	-3 (-4)
17	# acres public lands	NA	96,785	NA	139,900	NA	0	0	0	0	0	0	NA	NA	0	0
18	# of recreation sites	NA	60	NA	+	NA	0	0	0	0	0	0	NA	NA	0	0
	REDUCT.OF RISK															
	Critical Facilities															
19	# Facil. w/harmf.releas.	NA	18	NA	0	NA	0	-3	0	-18	-18	24	NA	NA	0	0
20	# other crit. facil.	NA	231	NA	0	NA	0	-147	0	0	-231	249	NA	NA	0	-17
	Prot./Avoid. of Harm															
21	# people vulnerable	NA	62,180	NA	6,199	NA	6,199	-44,670	0	0	0	188,620	NA	NA	0	-2,520
	Social Well Being															
22	# commun.vulnerable	NA	50	NA	8	NA	8	-27	0	0	0	21	NA	NA	0	-4
23	# resid.str.vulnerable	NA	23,460	NA	3,000	NA	2,340	16,850	0	0	0	73,240	NA	NA	0	-950
	IMPLEMENT. COSTS															
24	Structural Costs (millions)	NA	NA	NA	44.0	5,704.0	141.0	6,071.0	51.0	85.0	1,175	NA	NA	NA	NA	NA
25	Other Costs (millions)	NA	NA	NA	1,536.0	0.0	447.0	0.0	0.0	0.0	0	NA	NA	NA	NA	NA
															File: LMSALT3.wk4	

ST. LOUIS DISTRICT ANALYSIS

L1 - L2	Reductions are estimated for damages to unprotected areas.
L3 - L4	Increase due to levees that held in 1993.
L5	Decrease due to reduced flood fight effort.
L6 - L9	Increase due additional areas now flooded.
L10	Decrease is due to estimated 35% decrease in value of crop land not now protected.
L12	Estimate is based on environmental work group's assumption that a conversion of 15% of levee-protected agricultural lands to wetlands will occur (10% from inundation or saturation, 5% from annual flooding); group also assumed that proportion of resulting nonforested/forested wetlands is equal to existing ratio of these two wetland types within each District's study area.
L13	Estimate is based on judgement that more habitat will be available for T&E species because of converted levee-protected agricultural lands; habitat would be protected based on environmental work group's assumption that federal government would acquire these areas.
L14	Same as L12.
L15	Based on estimate by LMS H&H analyst that this alternative would protect 5 urban levee systems from flooding reliability of estimate of inundated area will improve when GIS data become available.
L17	Environmental work group assumed new nonforested/forested wetlands would be acquired by federal government.
L18	Estimate based on judgement that additional public lands will provide additional recreation sites.
L21 - L23	Reflects flooding in areas that were not inundated in 1993.
L24	Reflects construction costs.
L25	Reflects real estate/acquisition costs.
M12	Not evaluated.

M13	Not evaluated.
M14	Not evaluated.
M15	Based on rough estimates of existing acres of land use/land cover types protected/unprotected by levees; estimate of inundated area for this alternative is based on interpolation between Alternative 0 (raise levees) and base condition, and should be improved when GIS data become available.
M17	Not evaluated.
M18	Not evaluated.
N1 - N9	All increases reflect judgmental efforts to net the lower stages in unprotected areas versus the induced flooding in levee areas.
N10	Reflects 10% decrease in land values in levee areas with existing protection greater than 25-year.
N12-14, N17-18	Notching of agricultural levees estimated by LMS H&H analyst to be confined to area south of St. Louis; construction impacts and increased flooding due to notching assumed to result in no land use/land cover changes.
N15	Based on rough estimates of existing acres of land use/land cover types protected/unprotected by levees; areas protected by flooding for this alternative were estimated by LMS H&H analyst to include 5 urban and 8 agricultural levee systems; reliability of estimate of inundated area will improve when GIS data become available.
N19 - N23	Reflects the judgmental net impacts of additional storage.
N24	Constructions cost associated with notching levees with protection greater than 25-year.
N25	Reflects real estate/acquisition costs.
O12-14, O17-18	Flood reduction from raised levees assumed not to cause any land use/land cover changes; construction activities (borrow) also assumed not to change land use/land cover.
O15	Based on rough estimates of existing acres of land use/land cover types protected/unprotected by levees; reliability of estimate of inundated area will improve when GIS data are available.
P12-15, P17-18	It was assumed that no changes in land use/land cover would occur due to higher urban flood protection; construction impacts assumed to be confined to urban

	areas; LMS H&H analyst estimated that no additional areas would be flooded.
Q12-15, Q17-18	It was assumed that no changes in land use/land cover would occur due to flood protection for priority facilities; construction impacts assumed to be confined to urban areas; LMS H&H analyst estimated that no additional areas would be flooded.
R12-15, R-17-18	It was assumed that no changes in land use/land cover would occur due to flood protection for all facilities; construction impacts assumed to be confined to urban areas; LMS H&H analyst estimated that no additional areas would be flooded.
S12-14, S17-18	Land use/land cover assumed to be unaffected by increased flooding.
S15	Based on rough estimates of existing acres of land use/land cover types protected/unprotected by levees; LMS H&H analyst estimated areas protected by flooding to include 2 urban levee systems; reliability of estimate of inundated area will improve when GIS data become available.
V12-15, V17-18	Assumed that no changes in land use/land cover would occur due to flood reduction; construction impacts located out of floodplain; LMS H&H analyst estimated no change in number of levee systems flooded.
W12-14, W17-18	Assumed that no changes in land use/land cover would occur due to flood reduction; construction impacts located out of floodplain; LMS H&H analyst estimated one additional agricultural levee system protected from flooding.
W15	Reliability of estimate will improve when GIS data become available.

Glossary

100-year flood: A term commonly used to refer to the one percent annual chance flood. The 100-year flood is the flood that is equaled or exceeded once in 100 years on the average, but the term should not be taken literally as there is no guarantee that the 100-year flood will occur at all within a 100-year period or that it will not recur several times.

Acre-foot: An area of one acre covered with water to a depth of one foot. One acre-foot is 43,560 cubic feet or 325,851 gallons.

Action Alternative: For this assessment, an action alternative is a measure that has the potential to affect hydrologic and hydraulic conditions of the river system.

Actuarial rates: Insurance rates determined on the basis of a statistical calculation of the probability that a certain event will occur. Actuarial rates, also called risk premium rates, are established by the Federal Insurance Administration pursuant to individual community Flood Insurance Studies and investigations undertaken to provide flood insurance in accordance with the National Flood Insurance Act and with accepted actuarial principles, including provisions for operating costs and allowances.

Aggradation: The process of filling and raising the level of a streambed by deposition of sediment.

Agricultural levee: A levee that protects agricultural areas where the degree of protection is usually less than that of an urban area.

Antecedent: Having occurred prior to the time under consideration.

Authorization: House and Senate Public Works Committee resolutions or specific legislation which provides the legal basis for conducting studies or constructing projects. The money necessary for accomplishing the work is not a part of the authorization, but must come from an appropriation by Congress.

Backwater: The water surface of a stream raised above its normal level by a natural or artificial obstruction.

Bank and channel stabilization: The process of preventing bank erosion and channel degradation.

Basin: Drainage area of a lake or stream as: river basin.

Bottomland hardwoods: Tree species that occur on water-saturated or regularly inundated soils. Classified as wetlands, these areas contain both trees and woody shrubs.

cfs: The rate of flow (*see* Discharge) past a given point, measured in cubic feet per second. One cubic foot of water equals about 7 1/2 gallons.

Channel: A natural or artificial waterway which periodically or continuously contains flowing water.

Closure structure: A movable structure built along low points of a levee or floodwall, such as a street or railroad intersection, to prevent floodwaters from flooding the area protected by the levee or floodwall.

Collaborative approach: A commitment to working collectively to solve complex, interrelated concerns. A collaborative effort requires more than consultation, coordination, and seeing public input.

Community Assistance Program (CAP): The program established by the Federal Emergency Management Agency and intended to assure that communities participating in the NFIP are carrying out the flood loss reduction objectives of the program. The CAP provides needed technical assistance to NFIP communities and attempts to identify and resolve floodplain management issues before they develop into problems requiring enforcement action.

Community Rating System (CRS): A program developed by the Federal Emergency Management Agency to encourage -- by use of flood insurance premium reductions -- community and State activities that go beyond the basic NFIP requirements; the CRS gives communities credit for certain activities to reduce flood losses, facilitate accurate insurance rating, and promote the awareness of flood insurance.

Confluence: The place where streams meet.

Conservation tillage: Practices that reduce cultivation of soil, leave a protective vegetative layer on the surface, and thereby serve to reduce or minimize soil erosion.

Control dam: A dam or structure with gates to control the discharge from the upstream reservoir or lake.

Conveyance: A measure of the flow carrying capacity of a channel section.

Crest: The highest water level at a given location during a flood event.

Crib wall: A near vertical wall created by a framework of structural ties filled with soil.

Cross section: A plot which depicts the shape of the channel in which a stream flows.

Cumulative impacts: The impacts on the environment that result from the incremental impact of an action when added to other past, present and reasonably foreseeable actions; cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Dam: A barrier constructed across a valley for impounding water or creating a reservoir.

Damages prevented: The difference between damages occurring without the project and the damages with the project in place.

Degradation: A process of lowering the level of a streambed by scour and erosion.

Degree of protection: The magnitude of protection that a flood control measure is designed for, usually expressed as a statistical estimate of how often such a flood could occur; i.e., "a 100-year flood."

Depth of flow: The vertical distance from the bed of a stream to the water surface.

Deposition: The mechanical or chemical process through which sediments accumulate in a (temporary) resting place. The raising of a streambed by settlement of moving sediment that may be due to local changes in the flow such as during a flood event.

Design flood: The maximum amount of water for which a flood control project will offer protection. Selection is based on engineering, economic and environmental considerations.

Dike: An embankment to confine or control water and/or soil.

Discharge: The volume of fluid passing through a cross section of a stream per unit time.

Diversion channel: (1) An artificial channel constructed around a town or other point of high potential for flood damages to divert floodwater from the main channel to minimize flood damages. (2) A channel carrying water from a diversion dam.

Drainage basin: The area tributary to or draining into a lake, stream, or measuring site.

Drainage tiles: Short lengths of perforated pipe made of clay, concrete, or plastic installed in soil to remove water for the purpose of crop production.

Dredged material: The material removed in excavating or dredging in access canals, boat or navigation channels, drainage ditches, and lakes.

Earthfill dam: A dam in which the main section is composed principally of earth, gravel, sand, silt, and clay.

Ecosystem: Biological communities (including humans) and their environment (or watershed) treated together as a functional system of complementary relationships, including transfer and circulation of energy and matter.

Encroachments: Activities or construction within the floodway, including fill, new construction, substantial improvements, and other development, that may result in an increase in flood levels.

Environmental Assessment (EA): A planning report which presents the first thorough examination of alternative plans that positively demonstrates that the environmental and social consequences of a Federal action were considered. If the EA concludes that the proposal is a major Federal action significantly affecting the quality of the human environment, an environmental impact statement will be required.

Environmental Impact Statement (EIS): A report required by Section 102(2)(c) of Public Law 91-190 for all Federal actions which significantly affect the quality of the human environment. The EIS is a detailed and formal evaluation of the favorable and adverse environmental and social impacts of a proposed project and its alternatives.

Erosion: The wearing of a land surface by detachment and movement of soil and rock fragments through the action of moving water and other geological agents.

Executive Order 11988: The Floodplain Management Executive Order, issued in 1977, specifying the responsibilities of the Federal agencies in floodplain management. EO 11988 directed Federal agencies to evaluate and reflect the potential effects of their actions on floodplains and to include the evaluation and consideration of flood hazards in agency permitting and licensing procedures.

Feasibility study: An evaluation of a water resources problem to determine if a proposed work is technically, environmentally, and economically sound.

Federal levee: A levee system constructed by a Federal agency such as the U.S. Army Corps of Engineers, Natural Resource Conservation Service, or Bureau of Reclamation.

Flank levee: A levee constructed nearly perpendicular to the streamflow.

Flat pool: The pool on the upstream side of a navigation lock and dam where the water surface level is nearly horizontal or has a very mild slope.

Flood/flooding: A general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of river and/or tidal waters and/or the unusual accumulation of waters from any source.

Flood capacity: The flow carried by a stream or floodway at bank-full water level. Also, the storage capacity of the flood pool at a reservoir.

Flood control structures: Structures such as dams, dikes, levees, drainage canals, and other structures built to modify flooding and protect areas from floodwaters.

Flood crest: The highest or peak elevation of the water level during a flood in a stream.

Flood discharge: The quantity of water flowing in a stream and adjoining overflow areas during times of flood. It is measured by the amount of water passing a point along a stream within a specified period of time and is usually measured in cubic feet of water per second (cfs).

Flood Insurance Rate Map (FIRM): An official map of a community on which the Federal Emergency Management Agency has delineated both the special hazard areas and the risk premium zones applicable to the community. FIRMs typically identify the elevation of the one-percent annual chance flood and the areas that would be inundated by that level of flooding; they are used to determine flood insurance rates and for floodplain management.

Flood insurance: The insurance coverage provided through the National Flood Insurance Program.

Flood of record: The highest flood historically recorded at a given location.

Floodplain: Valley land along the course of a stream which is subject to inundation during periods of high water that exceed normal bank-full elevation.

Floodplain management regulations: Zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances that cover, for example, floodplains, grading, and erosion control and other regulations to control future development in floodplains and to correct inappropriate development already in floodplains.

Floodplain management: A decision-making process whose goal is to achieve appropriate use of the nation's floodplains. Appropriate use is any activity or set of activities that is compatible with the risk to natural resources and human resources. The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to watershed management, emergency preparedness plans, flood control works, and floodplain management regulations.

Floodplain resources: Natural and cultural resources including wetlands, surface water, groundwater, soils, historic sites, and other resources that may be found in the floodplain and that provide important water resources, living resources (habitat), and cultural/historic values.

Floodproofing: Techniques for preventing flood damage to the structure and contents of buildings in a flood hazard area.

Floodwall: Wall, usually built of reinforced concrete, to confine streamflow to prevent flooding.

Floodway: The channel of a river or other watercourse and the adjacent land areas that must be reserved to discharge the base flood without cumulatively increasing the water surface elevation more than a designated amount. The floodway is intended to carry deep and fast-moving water.

Flow rate: Rate of flow (discharge) at a specific location in a river or floodplain.

Freeboard: (1) Vertical distance between the normal maximum level of the surface of the liquid in a conduit, reservoir, tank, canal, etc., and the top of the sides of the conduit, reservoir, canal, etc. (2) An allowance in vertical distance above the design water surface level.

Frequency: The number of repetitions of a random process in a certain time period.

Gage: A device used for measuring environmental parameters (i.e., water levels, precipitation, temperature, water quality parameter, etc.)

Gaging station: A location on a stream where one or more variables are measured to record discharge and other parameters.

Geographic Information System (GIS): A computerized system designed to collect, manage, and analyze large volumes of spatially referenced and associated attribute data.

Gravity drainage outlets: (1) Outlets for gravity drains such as tiles, perforated conduits, etc., servicing an agricultural area and discharge into a drainage ditch. (2) Pipe, culvert, etc., used for dewatering ponded water by gravity from leveed areas.

Groin: A wall-like structure built perpendicular to the shore to trap sand and prevent beach erosion.

Habitat: The total of the environmental conditions which affect the life of plants and animals.

Headwaters: (1) The upper reaches of a stream near its source. (2) The region where groundwaters emerge to form a surface stream. (3) The water upstream from a structure.

Historic flows: The collection of recorded flow data for a stream during the period of time in which stream gages were in operation.

Hydraulic model: An analytical or physical scale model of a river used for engineering studies.

Hydraulics: The study and computation of the characteristics (e.g., water surface elevation, velocity, slope) of water flowing in a stream, river, or man-made channel.

Hydrograph: A graph showing, for a given point on a stream or channel, the discharge, water surface elevation, stage velocity, or other property of water with respect to time.

Hydrology: The studies of the properties, distribution, and circulation of water on the surface of the land, in the soil, and in the atmosphere.

Impact assessment: An analysis of changes in economic, environmental, or social resources in comparing 1993 flood base conditions with conditions resulting from implementation of scenario measures or action alternatives.

Impoundment: A body of water formed by collecting water, as a dam.

Land treatment measures: Measures used to reduce runoff of water to streams or other areas; techniques include maintenance of trees, shrubbery, and vegetative cover; terracing; slope stabilization; grass waterways; contour plowing; and strip farming.

Left or right bank of river: The left-hand or right-hand bank of a stream when the observer faces downstream.

Levee: A dike or embankment, generally constructed close to the banks of the stream, lake or other body of water, intended to protect the landward side from inundation or to confine the streamflow to its regular channel.

Level of protection: Same as degree of protection.

Lift: The difference in elevation between the upstream and downstream water surface levels in a lock and dam system.

Lift span bridge: A bridge having a movable span which remains horizontal while being lifted vertically by cables arranged through towers at both ends.

Lift station: A small wastewater pumping station that lifts the wastewater to a higher elevation when the continuance of the sewer at reasonable slopes would involve excessive depths of trench.

Lock: An enclosed part of a canal, waterway, etc., equipped with gates so that the level of the water can be changed to raise or lower from one level to another.

Lock operation: Locks fill and empty by gravity, with no pumps required to raise or lower the water level. To raise the water level, valves are opened above the upper gates and water flows into the lock through tunnels in both lock walls. This process is reversed to lower water in the lock. Valves are opened below the lower gates and water drains out of the lock through the tunnels. Gates at both ends of the lock open and close electrically after the proper water level has been reached.

Lower Mississippi River Basin: The portion of the Mississippi River Basin that drains into the Mississippi River from its confluence with the Ohio River to the Gulf of Mexico.

Lower Mississippi River: The reach of the Mississippi River from the confluence of the Ohio River at Cairo, Illinois, to the Gulf of Mexico.

Meander: The name given to the winding course of a stream or river. The shape and existence of the bends are a result of alluvial process and are not determined by the nature of the terrain through which the stream flows.

Meteorology: The science that deals with the atmosphere and its phenomena, especially with weather and weather forecasting.

Middle Mississippi River: The reach of the Mississippi River between its confluence with the Missouri River at St. Louis, Missouri, and its confluence with the Ohio River at Cairo, Illinois.

Miter gates: A type of gate commonly used to trap water in a lock chamber.

Mitigation: Any action taken to permanently eliminate or reduce the long-term risk to human life and property and the negative impacts on natural and cultural resources that can be caused by natural and technological hazards.

Mitigation lands: Lands acquired to offset adverse impacts of water resource (or other) projects.

Mouth of river: The exit or point of discharge of a stream into another stream, a lake, or the sea.

National Wetlands Inventory Project: Wetlands mapping on a national basis performed by the U.S. Fish and Wildlife Service to provide scientific information on the extent and characteristics of the nation's wetlands and consisting of detailed maps and status and trends reports.

Natural resources and functions of floodplains: Include, but are not limited to, the following: natural flood and sediment storage and conveyance, water quality maintenance, groundwater recharge, biological productivity, fish and wildlife habitat, harvest of natural and agricultural products, recreation opportunities, and areas for scientific study and outdoor education.

Navigation channel: The channel maintained in a body of water for the purpose of assuring a depth adequate for commercial vessels.

NGVD: Acronym for National Geodetic Vertical Datum. A vertical datum plane reference which has replaced mean sea level.

Non-Federal levee: Any levee or levee system constructed by a non-Federal agency, which is operated and maintained by a public sponsor.

Nonstructural measures: A term originally devised to distinguish techniques that modify susceptibility to flooding (such as watershed management, land use planning, regulation, floodplain acquisition, floodproofing techniques and other construction practices, and flood warning) from the more traditional structural methods (such as dams, levees, and channels) used to control flooding.

Normal precipitation (or temperature): The average precipitation over the most recent three decades based on a local or regional station, for which long-term records are available.

1% Flood: This is the same as a 100-year flood and is a flood which has a 1% chance of occurrence in any given year.

Overbank: The area in a river which lies between the bank of the main channel and the limits of the floodplain.

Oxbow lake: A lake formed in the meander of a stream, resulting from the abandonment of the meandering course due to the formation of a new channel course.

Planform: The form and size of a channel and overbank features as viewed from above.

Pile dike: A dike constructed of posts of similar piling driven into the soil.

Ponding area: An area reserved for collecting excess runoff preparatory to its being discharged whether by gravity or by pumping from a leveed area.

Pool: A small and rather deep body of quiet water as: water behind a dam.

Private levee: A levee constructed, owned, and maintained by one or more individual landowner(s).

Pumping station: A structure containing pumps which is used to evacuate runoff from behind levees during periods when high river levels prevent gravity drainage.

Reach: A length, distance, or leg of a channel or other watercourse.

Recurrence interval: The statistically derived probability of occurrence of a flood event converted to a time interval (e.g., a 1% chance flood = 100-year flood).

Regulatory floodplain: The area adjoining a river, stream, lake, or ocean that is inundated by a regulatory flood. In riverine areas, the floodplain usually consists of a regulatory floodway and regulatory flood fringe (also referred to as a floodway fringe). In coastal areas, the floodplain may consist of a single regulatory floodplain area or a regulatory high-hazard area and a regulatory low-hazard area.

Regulatory floodway: The area regulated by Federal, State, or local requirements to provide for the discharge of the base flood so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed one foot as the minimum standard set by the National Flood Insurance Program).

Rehabilitation: A major repair job. Usually involves considerable reconstruction of already existing structures.

Repetitive loss structure: A structure covered by a contract for flood insurance that has incurred flood related damage on two occasions during a 10-year period in which the cost of repair, on the average, equaled or exceeded 25 percent of the value of the structure at the time of each such flood event. (PL 103-325, Title V, Section 512)

Reservoir: A pond, lake, tank, basin, or other space, either natural or created in whole or in part by the building of a structure such as a dam, which is used for storage, regulation, and control of water for flood control, power, navigation, recreation, etc.

Retarding dam: A dam used to reduce the floodflow of a stream through temporary storage.

Revetment: (1) A facing of stone, concrete, sandbags, etc., to protect a streambank of earth from erosion. (2) A retaining wall.

Riprap: A layer, facing, or protective mound of randomly placed stones to prevent erosion, scour, or sloughing of a structure or embankment.

Riparian ecosystems: Distinct associations of soil, flora, and fauna occurring along a river, stream, or other body of water and dependent for survival on high water tables and occasional flooding.

River basin: A water resource basin is a portion of a water resource region defined by a hydrological boundary which is usually the drainage area of one of the lesser streams in the region.

River region: A water resource region is a major hydrologic area consisting of either the drainage area of a major river, such as the Missouri River, or the combined drainage areas of a series of streams.

Risk: The probability of being flooded.

Rock closing dams: In reaches of rivers where multiple channels are formed by islands, rock dikes that span the side channel, generally where it departs from the main channel, are called rock closing dams. They serve to direct flow to the main channel.

Rock dike: An embankment built principally of rock.

Runoff: Flow that is discharged from an area by stream channels; sometimes subdivided into surface runoff, groundwater runoff, and seepage.

Sandbag closure: A temporary closure structure consisting of sandbags. This closure may be found where a levee or floodwall has a sudden break in grade such as in a street crossing. Sandbags are used to close the street in times of high water to prevent flooding.

Scenario: For this assessment, a scenario is defined as a combination of policy and program changes that have the potential to affect the use of floodplains, and thus exposure to flooding.

Scour: The enlargement of a cross section of a stream by the removal of boundary material through the action of fluid motion.

Scour hole: Erosional holes developed as a result of breached levees. Locally called blow, blew, or blue holes.

Section 409 Hazard Mitigation Plan: A plan prepared as required by Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 by any jurisdiction that receives Federal disaster assistance.

Sediment: A collective term meaning an accumulation of soil, rock, and mineral particles transported or deposited by flowing water.

Sediment load: The total sediment composed of suspended load and bedload transported by a stream. The suspended load is composed of fine sediment transported in suspension, while bedload is composed of relatively coarse material transported along or near the bottom.

Sediment sample: A quantity of water-sediment mixture or deposited sediment that is collected to characterize some property of the sampled medium.

Sedimentation: A process that consists of five steps: (1) weathering, (2) erosion, (3) transportation, (4) deposition, and (5) digenesis, or consolidation into rock. Also refers to the gravitational settling of suspended particles.

Sedimentation basin: A basin or tank in which water or wastewater containing settleable solids is retained to remove (by gravity) a part of the suspended matter.

Shoal area: Patches of sand, gravel, or other hard bottom lying at shallow depths.

Sill: (1) A horizontal beam forming the bottom of an entrance to a lock. (2) Also, a low submerged dam-like structure built to control riverbed scour and current speeds.

Slack-water area: (1) In tidal waters, the area where tidal current velocity is at a minimum; especially the moment when a reversing current changes direction and its velocity is zero. (2) In streams, a place where there is very little current.

Slope: A portion of ground or a stream having an upward or downward inclination.

Slough: (1) A small muddy marshland or tidal waterway, which usually connects other tidal areas. (2) A tideland or bottomland creek. A side channel or inlet, as from a river or bayou, that may be connected at both ends to a parent body of water.

Spillway: A waterway of a dam or other hydraulic structure used to discharge excess water to avoid overtopping of a dam.

Spoil material: See Dredged material.

Spot dikes: A series of small dikes or levees filling low spots along a bank.

Stage: The elevation of the water surface above or below an arbitrary datum.

Stage-Discharge (rating) curve: A graph that defines the relationship between discharge and water surface elevation at a given location.

Standard project flood: A flood that may be expected from the most severe combination of meteorological and hydrological conditions that are reasonably characteristic of the geographical region involved, excluding extremely rare combinations.

Stem of a river: The primary axis of the river; the main channel.

Stop-log closure: Logs, planks, cut timber, steel, or concrete beams fitting into the guides between walls or piers to close an opening in a levee, dam, or conduit to the passage of water. The logs are usually placed one at a time.

Stream discharge: The volume of flow passing a stream cross section per unit time.

Stream gage: A device that measures and records flow characteristics such as water surface elevation at a specific location on a stream. Sediment transport measurements are usually made at stream gage sites.

Stream profile: A plot of the elevation of a streambed or water surface versus distance along the stream.

Structural measures: Measures such as dams, reservoirs, dikes, levees, floodwalls, channel alterations, high-flow diversions, spillways, and land treatment measures designed to modify floods.

Substantial damage: The amount of damage to a structure caused by flooding that may be sustained before certain regulatory and flood insurance requirements are triggered. As defined in NFIP regulations, a building is considered substantially damaged when the cost of restoring the building would exceed 50 percent of the market value of the structure.

Swale: (1) A slight depression, often wet and covered with vegetation. (2) A wide, shallow ditch, usually grassed or paved.

Swing span bridge: This is the span of a bridge across a navigable stream that rotates to allow tall ships to pass through the bridge.

Synopsis: A condensed statement or outline.

Tailwater: The water surface elevation downstream from a structure such as below a dam, weir, or drop structure.

Tainter gate: A semi-circular gate which opens and closes through pivoting on a shaft. It is used to control the flow of water over a spillway.

Tributary: A stream or other body of water that contributes its water to another stream or body of water.

Uncontrolled spillway: An overflow spillway having no control gates.

Upper Mississippi River Basin: The portion of the Mississippi River basin that is above the confluence of the Ohio River. It includes the Missouri River Basin.

Upper Mississippi River: The reach of the Mississippi River from its confluence with the Missouri River at St. Louis, Missouri, upstream to its headwaters at the outlet of Lake Itasca in Minnesota.

Urban levee: Levees which provide a high degree of flood protection (50- or 100-year level or greater) to predominantly urbanized areas.

Vertical lift gate: A gate that moves vertically in slots or tracks in piers and consists of a skin plate and horizontal girders which transmit the water load into the piers.

Watershed: The whole surface drainage area that contributes water to a collecting river or lake.

Wetlands: Those areas that are inundated by surface water or groundwater with a frequency sufficient to support and, under normal circumstances, does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include bottomland hardwoods, swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflow, mud flats, and natural ponds.

Wing dam: A wall, crib, row, pilings, stone jetty, or other barrier projecting from the bank into a stream for protecting the bank from erosion, arresting sand movement, or for concentrating the low flow of a stream into a smaller channel.

ATTACHMENT 7

ACRONYMS & ABBREVIATIONS

ac-ft	acre-feet
ACR	Acreage Conservation Reserve
ASCS	Agricultural Stabilization and Conservation Service (USDA)
ASFPM	Association of State Floodplain Managers
BIA	Bureau of Indian Affairs
BCR	Benefit/cost ratio
BOR	Bureau of Reclamation
CA	Cooperative Agreements
CDBG	Community Development Block Grant
CEA	Council of Economic Advisors
CELMS	St. Louis District (U.S. Army Corps of Engineers)
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CRS	Community Rating System
cfs	cubic feet per second
CFSA	Consolidated Farm Services Agency
CN	Curve Number
CNN	Cable News Network
COE	(U.S.) Army Corps of Engineers
CRP	Conservation Reserve Program
CVM	Contingent Valuation Method
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DNR	Department of Natural Resources
DOC	Department of Commerce
DOD	Department of Defense
DOI	(U.S.) Department of the Interior
DOT	Department of Transportation
EA	Environmental Assessment
EDA	Economic Development Administration
EEP	Environmental Easement Program
EIS	NEPA Environmental Impact Statement
EMP	Environmental Management Program
EMTC	Environmental Management Technical Center (an office of the National Biological Survey at Onalaska, WI)
ENSO	El Nino Southern Oscillation
EO	Executive Order
EOC	Emergency Operations Center(s) (U.S. Army Corps of Engineers)
EOP	Executive Office of the President
EPA	(U.S.) Environmental Protection Agency
EROS	Earth Resources Observation System
ERS	Economic Research Service
ESA	Endangered Species Act
EWP	Emergency Watershed Protection Program
EWRP	Emergency Wetlands Reserve Program
FAA	Federal Aviation Administration
FACTA	Food, Agriculture, Conservation and Trade Act of 1990 (the 1990 Farm Bill)
FCIC	Federal Crop Insurance Corporation
FCO	Federal Coordinating Officer
FEMA	Federal Emergency Management Agency
FFA	Future Farmers of America
FGDC	Federal Geographic Data Committee
FIPS	Federal Information Processing Standards
FIRM	Flood Insurance Rate Map
FmHA	Farmers Home Administration
FPMA	Floodplain Management Assessment
FR	Federal Register
FS	Forest Service
FSA	Food Security Act
FWS	U.S. Fish and Wildlife Service
FY	Fiscal Year
GIS	Geographic Information System
H&H	hydrologic and hydraulic
HEC	Hydrologic Engineering Center
HEL	Highly Erodible Land
HOME	HUD HOME Investment Parnership Program
HR	House of Representatives Bill
HREP	Habitat Rehabilitation and Enhancement Projects
HUD	Department of Housing and Urban Development
IFMRC	Interagency Floodplain Management Review Committee
IFSARE	InterFerometric Synthetic Aperture Radar for Elevation
L&D	Lock and Dam
LAWCON	Land and Water Conservation Fund
LIDAR	Light Detection and Ranging
LTRMP	Long Term Resource Monitoring Program
LMS	St. Louis District (U.S. Army Corps of Engineers)
LMVD	Lower Mississippi Valley Division (U.S. Army Corps of Engineers)
maf	million acre feet
MARC	Midwest Area River Coalition
MLRA	Major Land Resource Area
MM&MR	Major Maintenance and Major Rehabilitation
MR&T	Mississippi River and Tributaries Project
MRBA	Missouri River Basin Association
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MRC	Mississippi River Commission
NASA	National Aeronautics and Space Administration
NBS	National Biological Survey
NCD	North Central Division (U.S. Army Corps of Engineers)

NCR	Rock Island District (U.S. Army Corps of Engineers)
NCS	St. Paul District (U.S. Army Corps of Engineers)
NEPA	National Environmental Policy Act
NFIP	National Flood Insurance Program
NGO	Non-Governmental Organization
NGVD	National Geodetic Vertical Datum
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System (sites)
NPR	National Performance Review
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRD	Natural Resources District
NRI	National Resource Inventory
NWS	National Weather Service
Occ.	occurrences
OMB	Office of Management and Budget
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources
P&S	Principles and Standards for Planning Water and Related Land Resources
PL	Public Law
PFW	Partners for Wildlife
PPM	policy/program measure
RCC	Reservoir Control Center (U.S. Army Corps of Engineers, Missouri River Division)
RCRA	Resource Conservation and Recovery Act
RDA	Rural Development Administration
RFPE	Regulatory Flood Protection Elevation
RRSA	Refuge Revenue Sharing Act
R.M. or RM	river mile
S	Senate Bill
SAR	Synthetic Aperture Radar
SAST	Scientific Assessment and Strategy Team (of the IFMRC)
SBA	Small Business Administration
SCS	Soil Conservation Service (now NRCS)
SHPO	State Historic Preservation Office
SPF	Standard Project Flood
STATSGO	State Soil Geographic Data Base
SWAP	Small Wetlands Acquisition Program
T&E	threatened and endangered
TIGER	Topologically Integrated Geographically Encoded Reference
TVA	Tennessee Valley Authority
UCOWR	Universities Council on Water Resources
UDF	urban design flood
UMR	Upper Mississippi River
UMRBA	Upper Mississippi River Basin Association
UMRBC	Upper Mississippi River Basin Commission
UMRCC	Upper Mississippi River Conservation Committee
UMRS-EMP	Upper Mississippi River System Environmental Management Program
UNET	Mathematical hydraulic computer model that simulates one-dimensional, unsteady flows in rivers and floodplains
USACE	U.S. Army Corps of Engineers
USC	United States Code
USEPA	U.S. Environmental Protection Agency
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WRC	Water Resources Council
WRDA	Water Resources Development Act (of any year)
WRP	Wetland Reserve Program
WSEL	water surface elevation

(A number of acronyms are drawn from "Sharing the Challenge: Floodplain Management into the 21st Century" by the Interagency Floodplain Management Review Committee, in addition to those appearing this floodplain management assessment)

ATTACHMENT 8

Mapping/Spatial Data Index

The following abridged metadata lists describe several of the spatial data sets developed or modified for various FPMA analyses. A contact person or office is provided for additional information regarding each data set. Much of the GIS data used by the FPMA were already available from a variety of sources, but several data sets were created for the specific requirements of the FPMA and the FPMA study area. Numerous spatial data sets were provided by the Environmental Management Technical Center (of the National Biological Service), the SAST, the NRCS, and the EPA, and much data was already available in each of the five FPMA Corps Districts. To help those with INTERNET access, the home page addresses or other locations that can lead to some of these available data sets are provided below. In most cases a contact, address, or other information is provided at those home page sites to help locate information of interest.

Several of the data sets described below may also be available in other Districts than just the ones described but in slightly different formats. The Corps of Engineers link into the National Spatial Data Infrastructure ***(http://corps_geo1.usace.army.mil/)*** will be the USACE Geospatial Metadata and Data Server, a repository of Corp geospatial metadata that is accessible to all through the use of file transfer protocol (ftp) or Wide Area Information Server (WAIS) software. In the near future, it will also be a repository of Corps data. This site can be accessed at: ***http://corps_geo1.usace.army.mil/geo/ftp-gateway.html*** and includes locations for all Corps of Engineers District and Division offices and research laboratories.

The Corps of Engineers North Central Division has a Floodplain Management Assessment page at: ***http://www.usace.army.mil:80/ncd/fpma.htm*** and although this page is currently under development, it is intended to make the executive summary of the final report available at this site when the report is published in June.

The Corps of Engineers also maintains a 1993 Flood Data home page, a public access/browsing site for data and maps from the 1993 flood of the Mississippi and Missouri Rivers and their tributaries. That project was conducted by the Lower Mississippi Valley Division, with support from the Waterways Experiment Station Environmental Laboratory. Products include GIF Files of Flood Damages and summary tables of the data behind the map GIFs. There is also a map of the flood extent for the 1993 flood available for viewing. This home page is available at ***http://www.wes.army.mil/EL/flood/fl93home.html***.

The use of GIS as an analysis tool has been very helpful in determining impacts of the flood of 1993 as well as the alternative analyses. Many products were produced in both a soft copy and hard copy format. The products assisted District personnel in collecting, manipulating and interpreting the requirements of the Flood Plain Management Assesment. More detailed products could have been produced with additional resources in both funding and primarily personnel. Digital spatial data sets used for the FPMA include the following:

+ LANDSAT Landcover
+ 1993 Flood Extent (Satellite Imagery Interpreted and various aerial photographs)
+ Missouri River Basin States Association Land Use
+ Floodplain boundaries
+ Levees
+ Flood extents from UNET modelling
+ U.S.G.S. 7-1/2 Minute Quadrangles (various data from digitized or scanned quads)
+ U.S.G.S. Digital Line Graph files (Hypsography, roads, rails, hydrology, counties, states) from 1:24,000, 1:100,000 and 1:2 million scale data
+ National Wetland Inventory
+ Various critical facility data sets
+ Bluff lines
+ Hydrologic Unit boundaries
+ STATSGO soils
+ TIGER County Data
+ Geographic names Information System Data Sets
+ Government management areas
+ Bridges
+ and many others

Links to other sources of spatial data related to floodplain management are provided below:

The SAST Data Set List: ***http://edcwww2.cr.usgs.gov/dslist.html***

The USGS Generic Metadata for Upper Mississippi and Lower Missouri Data
http://edcwww.cr.usgs.gov/nsdi/html/sast/sast

The Environmental Management Technical Center: ***http://www.emtc.nbs.gov***

USGS Data Products: ***http://www.usgs.gov/data/index.html***

Natural Wetland Inventory Data: ***http://www.nwi.fws.gov***

The Environmental Protection Agency: ***http://www.epa.gov***

NOTICE: The U.S. Army Corps of Engineers assumes no responsibility for errors in the information documented. Similarly the U.S. Army Corps of Engineers assumes no responsibility for the consequences of inappropriate uses or interpretations of the data made by anyone to whom this data has been made available. The Corps bears no responsibility to inform users of any changes made to this data. Anyone using this data is advised that precision implied by the coverage may far exceed actual precision. Comments on this data are invited and the Corps would appreciate that documented errors be brought to staff attention.

DATASET: 1992 LANDSAT Landcover

DOCUMENTATION DATE: April 24, 1995
DATA THEME: Land Use / Land Cover
DESCRIPTION: Land cover as determined by LANDSAT satellite imagery interpretation using the Anderson Level 1 landuse/land cover classification system.
ABSTRACT: This coverage contains polygons representing different Anderson Level 1 land cover areas as seen by the LANDSAT satellite during 1992. The minimum resolution is 30 meters.

STATUS: Complete
GEOGRAPHIC AREA: The upper Mississippi and Missouri river drainage basins.
MAP PROJECTIONS: Universal Transverse Mercator (UTM) zone 15.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION:ARC/INFO V.6.1.1, Sun Sparkstation

INTENDED USE OF DATA: This layer was designed as a means to provide information about the land cover for the Upper Mississippi River Basin just prior to the flooding of 1993.
LIMITATIONS OF DATA: The positional accuracy of the coverage coordinates is a deductive estimate based on possible errors that may have occurred during each production step. These errors include source of data, and coordinate projection. The accuracy is estimated to be 170 feet.

COVERAGE DEVELOPERS: Scientific Assessment and Strategy Team (SAST).
CONTACT: SAST Database Administrator, EROS Data Center, U.S. Geological Survey
City: Sioux Falls
State or Province: SD
Postal_Code: 57198
Contact_Voice Telephone: 605 594 6091

ORIGINAL SOURCE INFORMATION:
MEDIA: 8mm tape
AUTHOR/AGENCY: Earth Satellite Corp.
PUBLISHED DATES: 1992
SCALE: 30 meter resolution
PROJECTION: UTM zone 15, NAD27

PROCEDURE USED TO CREATE THE DATA: EarthSat purchased from EOSAT the LANDSAT images for the midwest in 1992. They performed the imagery analysis to extract those areas that met the different classification parameters for Anderson Level 1. This ARC/INFO polygon coverage was then delivered to SAST (Scientific Analysis Assessment Team) a multi-agency workgroup working at EROS Data Center in Sioux Fall, SD. No changes were made by the SAST group. This data was then given to the US Army Corps of Engineers. More detailed information about EarthSat's analysis techniques can be obtained from EarthSat, Corp. Their address and telephone number is as follows:

Earth Satellite Corp.
6011 Executive Boulevard
Suite 400
Rockville, MD 20852
(301) 231-0660.

REVISIONS MADE TO DATA: none
REFERENCES: none
COMMENTS:none

Polygon Attribute File Items (PAT)
LUCODE -The Anderson Level 1 codes.
0 = Not in the Study area.
1 = Urban or developed
2 = Agriculture
3 = Rangeland
4 = Forested Land
5 = Water
6 = Wetlands
7 = Barren
252=Clouds/ Cloud Shadow
ACREAGE - the number of acres for each polygon.

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DATASET: 1993 FLOOD EXTENT

DOCUMENTATION DATE: April 19, 1995
DATA THEME: Boundaries
DESCRIPTION: The extent of flooding in July of 1993 as captured by LANDSAT satellite imagery.
ABSTRACT: This coverage shows the areas that had standing water during the July-August 1993 flooding in the Midwest. An algorithm was used to extract these areas from the LANDSAT imagery and convert it into a polygon based ARC/Info coverage.

STATUS: Complete
GEOGRAPHIC AREA: The upper Mississippi and Missouri river drainage basins (St. Paul, MN to Cairo, IL and Gavins Pnt. to the confluence)
MAP PROJECTIONS: Universal Transverse Mercator (UTM) zone 15.

MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION:ARC/INFO V.6.1.1, Sun Sparkstation

INTENDED USE OF DATA: This layer was designed as a means to provide information about the extent of flooding during the peak flooding in 1993.
LIMITATIONS OF DATA: The positional accuracy of the coverage coordinates is a deductive estimate based on possible errors that may have occurred during each production step. These errors include source of data, and coordinate projection. The accuracy is estimated to be 170 feet.

COVERAGE DEVELOPERS: Scientific Assessment and Strategy Team (SAST).
CONTACT: SAST Database Administrator, EROS Data Center, U.S. Geological Survey
City: Sioux Falls
State or Province: SD
Postal_Code: 57198
Contact_Voice Telephone: 605 594 6091

ORIGINAL SOURCE INFORMATION:
MEDIA: 8mm tape
AUTHOR/AGENCY: Earth Satellite Corp.
PUBLISHED DATES: 1993
SCALE: 30 meter resolution
PROJECTION: UTM zone 15, NAD27
PROCEDURE USED TO CREATE THE DATA: EarthSat purchased from EOSAT the LANDSAT images for the midwest during the peak flooding. They performed the imagery analysis to extract those areas that had standing water. This ARC/INFO polygon coverage was then delivered to SAST (Scientific Analysis Assessment Team) a multi-agency workgroup working at EROS Data Center in Sioux Fall, SD. No changes were made by the SAST group. This data was then provided to the US Army Corps of Engineers.
REVISIONS MADE TO DATA: none
REFERENCES: none
COMMENTS:none
Polygon Attribute File Items (PAT)
GRID-CODE - The number of Grid cell from which the following attribute iinformation was extracted.
RECNUM - Not Known
NEW-CODE - This attribute contains the information detailing which polygon are clouds, isolated water, and overbank flooding.
0 = blank, nothing
250=Overbank flooding
252=Isolated water, lakes, ponds, etc.
255=Clouds
999=blank, nothing

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DATASET: Missouri River Basin States Association

DOCUMENTATION DATE: March 10,1995
DATA THEME: Land Use
DESCRIPTION: Land Use data is Anderson level 2 with user defined Anderson level 3 for some classifications. The area covered includes Ponca, Nebraska to Rulo, Nebraska. Original Hardcopy base maps were based on 47 1:24,000 U.S.G.S. quads.
ABSTRACT: This coverage contains polygons representing different land classifications.

STATUS: Done
GEOGRAPHIC AREA: Ponca to Rulo, Nebraska
MAP PROJECTIONS: Albers Equal Area.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO v. 6.1.2 Sun Sparcstation

INTENDED USE OF DATA: This data was designed to be used as a means to determine acreage of land use flooded by alternative.
LIMITATIONS OF DATA: Land Use polygons are no more accurate than 13 meters of its true location on the face of the earth.

COVERAGE DEVELOPERS: U.S. Army Corps of Engineers, Omaha District.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers,.Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 7221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Plastic and Mylar maps
AUTHOR/AGENCY: Missouri River Basin States Association
PUBLISHED DATE(S): 1982
SCALE:1:24,000
PROJECTION:Geographic Nad27

PROCEDURE USED TO CREATE THE DATA: Sheets 1 - 30 were scanned and vectorized by GEONEX via the Kansas City Scanning Contract. Sheets 31 - 47 were digitized on an ALTEK digitizer by the Corps of Engineers. Some shrinkage was noted on the plastic overlays digitized. The Surveys, Mapping and GIS section attributed sheets 1 - 47 with the appropriate land use code. An AML was written to translate the code into various textual descriptions for each Anderson Level.

ARC Attribute File Items (AAT)

LENGTH: Length of arcs in meters. (Computer generated)

Polygon Attribute File Items (PAT)

AREA: Area of the polygon in square meters. (Computer generated)

PERIMETER: Length of the polygon perimeter in meters. (Computer generated)

CODE: The land use code for each polygon.

LEVEL-I: Anderson Level 1 code.

1 = Urban or Built UP
2 = Agriculture
3 = Forest
4 = Open Water Wetland
5 = Sand Bars and Vegetated Wetland
6 = Barren

TEXT-I: Textual description of each level (ex Forest).

LEVEL-II: Anderson Level 2 Code.

11 = Residential
12 = Commercial
13 = Industrial
12/13 = Mixed Commercial Industrial
14 = Transportation
15 = Utilities
16 = Waste Water Treatment
17 = Solid Waste Disposal
18 = Institutional
19 = Parks and Recreation
21 = Cropland
22 = Specialty Crops
23 = Confined Feeding Operation
24 = Grassland/Hayland/Pasture
31 = Flood Plain Woodland
32 = Shrubland
41 = Missouri River Main Channel
42 = Missouri River Side Channels and Backwaters
43 = Tributary Rivers and Streams
44 = Intermittent Streams and Watercourses
45 = Lakes
46 = Ponds
51 = Sandbars
52 = Emergent
53 = Shrub/Forest
53/52 = Mixed Vegetated Wetlands
61 = Mines, Quarries, Gravel Pits, Etc.
62 = Sand Dunes
63 = Other

TEXT-II: Textual Description of each level (ex Sand Dunes).

LEVEL-III: Anderson Level 3 Code.

11.1 = Single Family
11.2 = Mobile Home
11.3 = Multi-family
13.1 = Agricultural Storage
14.1 = Airports
14.2 = River Terminals
14.3 = Land-based Terminals
14.4 = Interstate Highways
14.5 = Railroads
15.1 = Power Plants
15.2 = Water Supply
21.1 = Center-pivot Irrigation
31.1 = Over 75% Crown Cover
31.2 = 25-74% Crown Cover
31.3 = Recently Cleared
41.1 = Mudflats
42.1 = Mudflats
45.1 = Mudflats
46.1 = Mudflats

TEXT-III: Textual Description of each level (Ex Railroads).

==

DATASET: Converted 1:24,000 U.S.G.S quads.

DOCUMENTATION DATE: March 10,1995

DATA THEME: Blue, Black, Photo Update and Redbrown Separate.

DESCRIPTION: Intergraph Design files were created from U.S.G.S. mylar separates. The area covered includes Ponca, Nebraska to Rulo, Nebraska. Original Hardcopy base maps were based on 59 1:24,000 U.S.G.S. quads.

ABSTRACT: These coverages contain arcs representing different themes on a 1:24,000 U.S.G.S. quad.

STATUS: Done
GEOGRAPHIC AREA: Niobrara to Rulo, Nebraska
MAP PROJECTIONS: Nebraska State Plane Zone South.
MAP UNITS: feet
DATUM: NAD27
SOFTWARE VERSION: Intergraph Inroads and Inexpress

INTENDED USE OF DATA: This data was designed to be used as a means of automatically generating flood outlines via UNET modeling.
LIMITATIONS OF DATA: Arcs generated are no more accurate than 13 meters of its true location on the face of the earth.

COVERAGE DEVELOPERS: U.S. Army Corps of Engineers, Omaha District.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 7221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Mylar separates.
AUTHOR/AGENCY: U.S.G.S.
PUBLISHED DATE(S): various
SCALE:1:24,000
PROJECTION:Geographic Nad27

PROCEDURE USED TO CREATE THE DATA: U.S.G.S. separates were scanned at 800 dpi, warped into Nebraska Stateplane coordinates, vectorized and converted into Intergraph 3-D design files. The quad conversion was accomplished by Computer Graphics Atlanta via the Kansas District Scanning Contract. The data was later converted into ARC/INFO with an AML created by the Omaha District that creates a coverage for each layer of the design file.

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DATASET: Converted 1:24,000 U.S.G.S Digital Line Graph files.

DOCUMENTATION DATE: March 10,1995
DATA THEME: Hypsography(contours), Roads, Rail, Hydrology.
DESCRIPTION: DLG files were converted into ARC/INFO and projected from UTM to Nebraska State Planes Zone South. All layers other than hypsography were converted into Intergraph 2-D design files. ARC/INFO can not create 3-D design files so Jon Kragt created a 3-D DXF file which was imported into Intergraph. The Intergraph design files edge matched to the quads that were converted through the Kansas District Scanning Contract.
ABSTRACT: These coverages contain arcs representing different themes on a 1:24,000 U.S.G.S. quad. Only the contours contain elevation values.

STATUS: Done
GEOGRAPHIC AREA: Albaton to Pacific Junction, Nebraska
MAP PROJECTIONS: Nebraska State Plane Zone South.
MAP UNITS: feet
DATUM: NAD27
SOFTWARE VERSION: Intergraph Inroads and Inexpress Design Files.

INTENDED USE OF DATA: This data was designed to be used as a means of automatically generating flood outlines via UNET software.
LIMITATIONS OF DATA: Arcs generated are no more accurate than 13 meters of its true location on the face of the earth.

COVERAGE DEVELOPERS: U.S.G.S. and the Army Corps of Engineers, Omaha District.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102
Phone # (402) 221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Digital Line Graphs.
AUTHOR/AGENCY: U.S.G.S.
PUBLISHED DATE(S): various
SCALE:1:24,000
PROJECTION:Geographic Nad27

PROCEDURE USED TO CREATE THE DATA: See description.

==

DATASET: Power Plants, Power Lines and Substations.

DOCUMENTATION DATE: March 10,1995
DATA THEME: Power Plants, Power Lines and Substations.
DESCRIPTION: This map shows locations of power plants, power lines and substations for Iowa and Nebraska. Various attributes show line substation and power plant types.
ABSTRACT: These coverages contain arcs and points showing Power Lines, Power Plants and Substations for Iowa and Nebraska.

STATUS: Done

GEOGRAPHIC AREA: Iowa and Nebraska
MAP PROJECTIONS: Albers Equal Area.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO version 6.1.2.

INTENDED USE OF DATA: This data was designed to be used in computing flood alternative impacts of power plants and substations.
LIMITATIONS OF DATA: Arcs and points generated are derived from a 1:1,267,200 with unknown accuracies.

COVERAGE DEVELOPERS: Western Area Power Administration.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Paper maps
AUTHOR/AGENCY: W.A.P.A.
PUBLISHED DATE(S): 1994
SCALE:1:1,267,200
PROJECTION:Unknown - Transformed from township and Range Lines

PROCEDURE USED TO CREATE THE DATA: Paper maps were digitized on an ALTEK digitizer using ArcEdit software. Coordinates were transformed from township and Range lines. Arcs and points were attributed by the Surveys, Mapping and GIS Section, Omaha District from data listed on the paper map.

ARC Attribute File Items (AAT)
LENGTH: Length of arcs in meters. (Computer generated)
KV: Kilo Volts
OWNERSHIP: Owner of the Power Line.

Polygon Attribute File Items (PAT)
AREA: Area of the polygon in square meters. (Computer generated)
PERIMETER: Length of the polygon perimeter in meters. (Computer generated)
FACILITY: Power plat or Substation.
POWERPLANT
SUBSTATION
OWNERSHIP: Ownership of Facility.
FEDERAL
PUBLIC
PRIVATE
POWERSOURCE: Power source of power plant.
DIESEL
HYDRO
NUCLEAR
STEAM
CITY: Town or location of facility.
MEGAWATTS: The amount of power generated.

==

DATASET: Bluff line delineation.

DOCUMENTATION DATE: March 10,1995
DATA THEME: Bluff Line Delineation on the Missouri River.
DESCRIPTION: This map shows the location of the bluff line from Gavins Points Dam to Rulo, Nebraska. The bluff line delineation is only for the Missouri river.
ABSTRACT: This coverage contains arcs and a polygon of the Missouri River Flood Plain.

STATUS: Done
GEOGRAPHIC AREA: Gavins Point Dam to Rulo, Nebraska
MAP PROJECTIONS: Albers Equal Area.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO version 6.1.2.

INTENDED USE OF DATA: This data was designed to be used to illustrate the Missouri River Flood plain in conjunction with the Computer generated alternatives. The data is also used to calculate Bluff to Bluff acreage counts as well as supplement the land use data where data does not exist.
LIMITATIONS OF DATA: Arcs and polygons generated are derived from 1:24,000 U.S.G.S. maps and are no more accurate than 13 meters relative to true ground distance.

COVERAGE DEVELOPERS: Surveys, Mapping and GIS Section.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Digital 1:24,000 quads

AUTHOR/AGENCY: U.S. Army Corps of Engineers
PUBLISHED DATE(S): various
SCALE:1:24,000
PROJECTION: Albers Equal Area

PROCEDURE USED TO CREATE THE DATA: Bluff lines were generated by following abrupt changes in the contour density of a digital 1:24,000 U.S.G.S. quad. "Heads up" digitizing techniques were used to directly create the lines by the Surveys, Mapping and GIS Section.

Arc Attribute File Items (AAT)
LENGTH: Length of arcs in meters. (Computer generated)
Polygon Attribute File Items (PAT)
AREA: Area of the polygon in square meters. (Computer generated)
PERIMETER: Length of the polygon perimeter in meters. (Computer generated)

DATASET: 8 Hydro Section Alternatives.

DOCUMENTATION DATE: March 10,1995
DATA THEME: Hydro section Alternatives (Flood Outlines).
DESCRIPTION: This map shows the Alternative flood polygons automatically generated by the Omaha District Hydro section
ABSTRACT: These coverages contain arcs and a polygons of the 8 Alternatives generated by the Omaha District Hydro Section.

STATUS: Done
GEOGRAPHIC AREA: Omaha to Rulo, Nebraska within the Missouri River Flood Plain.
MAP PROJECTIONS: Albers Equal Area.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO version 6.1.2.

INTENDED USE OF DATA: This data was created in Intergraph and converted to ARC/INFO to calculate impacts based on No Reservoirs, No levees, Levee Setbacks, Maximum Levees, 5% Reduction, 10% Reduction, 25 year notch and Base conditions. The 8 polygons were used to calculate acreage impacts by land use by county and critical facility impacts.
LIMITATIONS OF DATA: Arcs and polygons generated are derived from a surface created in Intergraph from 1:24,000 U.S.G.S. contour information and Corps Provide Spot elevations. The surface created generated arcs that are accurate to maps and are no more accurate than 50-100 meters relative to true ground distance. The Intergraph system could not handle all the data provided and thinning of elevation information was required for the 120 mile stretch. Due to the thinning, the arcs have a wave pattern when the user is zoomed in to larger scales.

COVERAGE DEVELOPERS: Hydro Section.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Digital 1:24,000 quads and USACE spot elevations
AUTHOR/AGENCY: U.S.G.S. and the U.S. Army Corps of Engineers
PUBLISHED DATE(S): various
SCALE:1:24,000
PROJECTION: Nebraska State Plane Zone

PROCEDURE USED TO CREATE THE DATA: The Alternatives were generated from 1:24,000 U.S.G.S quads and corps provided spot elevations. Intergraph INroads software was used to generate a surface and UNET software was used to generate the flood outline. The intergraph design files were then imported into arc/info, the line work was cleaned in arcedit and polygons were generated in ARC/INFO.

Arc Attribute File Items (AAT)
LENGTH: Length of arcs in meters. (Computer generated)
Polygon Attribute File Items (PAT)
AREA: Area of the polygon in square meters. (Computer generated)
PERIMETER: Length of the polygon perimeter in meters. (Computer generated)

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DATASET: Hydro Section Flood Outlines.

DOCUMENTATION DATE: March 10,1995
DATA THEME: Hydro section Alternatives (Flood Outlines).
DESCRIPTION: This map shows the 1993 flood event from Omaha to Rulo, Nebraska in the Missouri river Flood Plain.
ABSTRACT: These coverages contain arcs and a polygons of the 1993 Flood event from Omaha to Rulo, nebraska.

STATUS: Done
GEOGRAPHIC AREA: Omaha to Rulo, Nebraska within the Missouri River Flood Plain.
MAP PROJECTIONS: Albers Equal Area.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO version 6.1.2.

INTENDED USE OF DATA: This data was created in Intergraph and converted to ARC/INFO to calculate impacts based on the 1993 event.
LIMITATIONS OF DATA: Arcs and polygons generated are derived from rectified aerial photography. The imagery was "rubber sheeted" to 1:100,000 TIGER data.

COVERAGE DEVELOPERS: Hydro Section.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: 1" = 1000' Black and White Aerial Photography
AUTHOR/AGENCY: U.S. Army Corps of Engineers
PUBLISHED DATE(S): 1993
SCALE:1:12,000
PROJECTION: N/A

PROCEDURE USED TO CREATE THE DATA: The flood outline was generated by "rubber sheeting" Aerial photography to TIGER data. The flood outlines were created by "head up" digitizing the photo interpreted flood outlines from the imagery. The outlines were then converted in Intergraph, cleaned, and projected into Albers Equal Area.

Arc Attribute File Items (AAT)
LENGTH: Length of arcs in meters. (Computer generated)
Polygon Attribute File Items (PAT)
AREA: Area of the polygon in square meters. (Computer generated)
PERIMETER: Length of the polygon perimeter in meters. (Computer generated)

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DATASET: Interior, Exterior and Main Channel Flooding.

DOCUMENTATION DATE: March 10,1995
DATA THEME: Interior, Exterior and Main Channel Flooding.
DESCRIPTION: *This map shows* the 1993 flood event from Omaha to Rulo, Nebraska in the Missouri river Flood Plain with enhanced information derived from public meeting and ground truthing regarding the type of flooding that occurred in each area.
ABSTRACT: These coverages contain arcs and a polygons of the 1993 Flood event from Omaha to Rulo, nebraska.

STATUS: Done
GEOGRAPHIC AREA: Omaha to Rulo, Nebraska within the Missouri River Flood Plain.
MAP PROJECTIONS: Albers Equal Area.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO version 6.1.2.

INTENDED USE OF DATA: This data was created in Intergraph and converted to ARC/INFO to calculate impacts based on the 1993 event.
LIMITATIONS OF DATA: Arcs and polygons generated are derived from rectified aerial photography. The imagery was "rubber sheeted" to 1:100,000 TIGER data. Information from public meetings and field investigation was incorporated into the data to determine the type of flooding.

COVERAGE DEVELOPERS: Hydro Section.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Hydro Section Flood Outline
AUTHOR/AGENCY: U.S. Army Corps of Engineers
PUBLISHED DATE(S): 1993
SCALE:1:100,000
PROJECTION: N/A

PROCEDURE USED TO CREATE THE DATA: The flood outline was generated by "rubber sheeting" Aerial photography to TIGER data. The flood outlines were created by "*head up*" *digitizing the photo* interpreted flood outlines from the imagery. The outlines were then converted in Intergraph, cleaned, and projected into Albers Equal Area. Information from public meetings and field investigation was incorporated into the data regarding the type of flood that occurred in a particular area.

Arc Attribute File Items (AAT)
LENGTH: Length of arcs in meters. (Computer generated)
Polygon Attribute File Items (PAT)
AREA: Area of the polygon in square meters. (Computer generated)
PERIMETER: Length of the polygon perimeter in meters. (Computer generated)
DESCRIPTION: Color of the area of interest
DRY LAND
ORANGE
STRIPED
YELLOW
DESCRIPTION2: The Type of Flooding
INTERIOR AND TRIBUTARY FLOODING

INTERIOR, TRIBUTARY AND LEVEE OVERTOP FLOODING
MAIN CHANNEL AND LEVEE OVERTOP
AG_CLASS
0
1
2
==

DATASET: Flood Type By County By Landuse with Acreage counts.

DOCUMENTATION DATE: March 10,1995
DATA THEME: Acreage counts by county by land use type.
DESCRIPTION: These 72 maps show each of the 8 alternatives for 9 counties with land use and acreage counts. Comma delimited ascii files were created depicting the land use and acres impacted for each county. The ascii files were then imported into a spread sheet for social and economic analysis, as well as, critical facility impacts.
ABSTRACT: These coverages contain arcs and a polygons of the 8 Alternatives studied for the Flood Plain Management Assessment and are broken dawn by county and alternative.

STATUS: Done
GEOGRAPHIC AREA: Omaha to Rulo, Nebraska within the Missouri River Flood Plain.
MAP PROJECTIONS: Albers Equal Area.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO version 6.1.2.

INTENDED USE OF DATA: This data was created by a UNION and CLIP process in ARC/INFO. The coverages used in the creation of this product include the 8 alternatives, county boundaries, the Omaha District Civil Boundary and the Missouri River Basin land use data.
LIMITATIONS OF DATA: Arcs and polygons generated are derived from the data listed in INTENDED USE OF DATA. The accuracy is therefore no better than the least accurate coverage used. Estimate the accuracy is no better than 50 meters horizontal distance on the ground.

COVERAGE DEVELOPERS: Surveys, Mapping and GIS Section.
CORPS CONTACT: Jon Kragt, US Army Corps of Engineers, Omaha District, Surveys, Mapping and GIS Section, 215 North 17th Street, Omaha, NE 68102 Phone # (402) 221-4614.
FAX: (402) 221-4614
E-MAIL: jkragt@snmgis1.mro.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Omaha Civil Boundary, Missouri River Basin Land Use, County Boundary and the 8 Alternatives.
AUTHOR/AGENCY: U.S. Army Corps of Engineers
PUBLISHED DATE(S): N/A Created in 1995
SCALE:Various
PROJECTION: Albers Equal Area

PROCEDURE USED TO CREATE THE DATA: The Bluff Line polygon was UNIONed with the Missouri River Basin States Association (MRBSA) Land Use Data. The MRBSA data did not always extend bluff to bluff, therefore, all polygons not classified with a land use code was classified 9999 or "unclassified". The bluff_line_land_use map was clipped "Cookie Cut" by the 8 Alternatives and the resulting coverages where clipped by the 9 counties. Acres were then calculated and placed in an item called ACRES. The statistics function was used to generate acreage counts by land use and unloaded into a comma delimited ascii file. This resulted in 72 maps.

Arc Attribute File Items (AAT)
LENGTH: Length of arcs in meters. (Computer generated)

Polygon Attribute File Items (PAT)
AREA: Area of the polygon in square meters. (Computer generated)
PERIMETER: Length of the polygon perimeter in meters. (Computer generated)
CODE: see MRBSA
LEVEL-I: see MRBSA
TEXT-I: see MRBSA
LEVEL-II: see MRBSA
TEXT-II: see MRBSA
LEVEL-III: see MRBSA
TEXT-III: see MRBSA
ACRES: Calculated from Area

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DATASET: ROCK ISLAND LEVEES

DOCUMENTATION DATE: June 3, 1994
DATA THEME: embankments
DESCRIPTION: Levee centerlines as arcs and the areas they protect as polygons in the Rock Island District.
ABSTRACT: This coverage contains polygons representing the areas protected by levees. Each polygon is comprised of arcs representing the centerline of levees or other types of protection, and arcs representing the extent of the levee district, which is an elevation that corresponds to the level of protection (top of the levee). This coverage contains the all levee districts that were either built with federal dollars or asked to have their levees inspected for eligibility in the PL-84-99

program, or received funding from Federal agencies for flood damage in 1993.

STATUS: 90% done
GEOGRAPHIC AREA: Rock Island District
MAP PROJECTIONS: Universal Transversal Mercator (UTM) zone 15.
MAP UNITS: meters
DATUM: NAD27
SOTFWARE VERSION: ARC/INFO v. 6.1.1 Sun Sparkstation

INTENDED USE OF DATA: This data was designed to be used as a means to locate levees in the Rock Island District and to be able to quickly access information needed in emergencies.
LIMITATIONS OF DATA: The levee centerlines were digitized off of USGS 7.5 minute quadrangle maps. The accuracy is estimated to be within 60 feet of its true location. The arcs defining the extent of protection were hand drawn onto the quad sheet using the topography contours as a guide. The accuracy is estimated to be within one-half of a contour as to its true extent of protection.

COVERAGE DEVELOPER: U.S. Army Corps of Engineers, Rock Island District
CORPS CONTACT: Thomas DeWitte, US Army Corps of Engineers, Rock Island District, Operations Division, Clock Tower Building, P.O. Box 2004, Rock Island, IL 61204-2004. Phone # (309) 794-5674.

ORIGINAL SOURCE INFORMATION:
MEDIA: Paper copy of map.
AUTHOR/AGENCY: U.S. Geological Survey
PUBLISHED DATE(S): 1948-1993
SCALE: 1:24,000
PROJECTION: Stateplane

PROCEDURE USED TO CREATE THE DATA: Corps of Engineers survey maps were used to accurately locate the levees on USGS 7.5 minute maps. When survey mapping data was not available, Legal locational information such as section, range and township were used to locate the correct levee on the USGS map. District boundaries were hand drawn onto the USGS 7.5 minute maps using Corps of Engineers survey records as a reference. Contour lines were used as a map reference for the boundary lines. Levee centerlines and *district boundaries were digitized on an ALTEK digitizing table using the software ARC/INFO.* ARC/INFO software was then used to project the coverage from latitude/longitude to UTM zone 15.
COMMENTS: None

ARC Attribute File Items (AAT)

LENGTH:	Length of arcs in meters. (Computer generated)
LINE_TYPE:	Type of feature being represented by the ARC. LEVEE - Centerline of an earthen levee. DISTRICT-Elevation line or distrct taxing base extent that defines that part of the levee district not defined by the levee or other form of protection. CONC. WALL-Concrete wall RAILROAD-Railroad embankment
NAME:	Name of the levee district.

Polygon Attribute File Items (PAT)

AREA:	Area of the polygon in square meters. (Computer generated)
PERIMETER:	Length of the polygon perimeter in meters. (Computer generated)
NAME:	Name of the levee district.
STATE:	State abbreviation.
COUNTY:	County name.
MAJOR_STREAM:	Name of the stream having the main effect on the levee district.
SPONSORSHIP:	Name of the sponsor responsible for maintaining the levee.
OWNERSHIP:	The type of taxing body sponsor. DRAINAGE DISTRICT LEVEE DISTRICT SANITARY DISTRICT DRAINAGE & LEVEE DISTRICT COUNTY CITY PRIVATE FEDERAL
LENGTH(MILES):	Length of the levee system as determined by field survey.
PROTECT_YRS:	Level of protection in terms of years as determined by analysis of the hydraulic characteristics of the drainage basin.
UPSTRM_ELEV:	Elevation of the upstream end of the MAJOR_STREAM river levee crown. This is usually the corner where the main river levee and the upstream tie-back flank levee meet. Elevation is measured in feet above sea level (M.S.L. 1929).
UPSTRM_HEIGHT:	Approximate height of the MAJOR_STREAM river levee crown at the same location as the UPSTRM_ELEV, measured *in feet above the landside ground elevation.*
DWNSTRM_ELEV:	Elevation of the downstream end of the MAJOR_STREAM river levee crown or downstream tie-back flank levee where overtopping is first estimated to occur. Elevation is measured in feet above sea level (M.S.L.1929).
DWNSTM_HEIGHT:	Approximate height of the major stream river levee crown in feet above the landside ground elevation, at the downstream end of the MAJOR_STREAM river levee where the DWNSTRM_ELEV was measured.
LEVEE_MATERL:	Main type of soil used in the levee construction.
FOUND_MATERL:	Main type of soil in the foundation at the base of the levee.
PL_84_99:	Whether or not the levee district meets PL-84-99 *minimum conditions to be eligible for Federal cost sharing support in* event of levee failure or overtopping.

	YES = Levee is eligible for federal cost sharing.
	NO = Levee does not meet the minimum requirements to be eligible.
FEMA_CERT:	Whether or not the levee district meets FEMA's minimum conditions for certification. Levee must provide at least a 100 year level of protection.
	YES = Levee meets FEMA's minimum conditions.
	NO = Levee does not meet FEMA's minimum conditions.
ACRES:	Area protected by the levee as measured in acres.
CONSTRUCTION:	Whether or not Federal Funds were used to construct the levee.
	F = Federal funds were used.
	N = Non-Federal funds were used.
LEVEE_TYPE:	Type of area protected by the levee.
	A = Agricultural
	AR = Agricultural and Residental
	E = Environmental
	I = Industrial
	R = Residental
	S = Sanitary
FAILURE_TYPE:	Type of failure in 1993.
	Overtopping = Levee was overtopped before any structural failure occurred.
	Breach = Levee failed when water level was below the crown of the levee.
FAILURE_DATE:	Date that the initial failure occurred.
FLOODED_1993:	Whether or not the levee district was flooded in 1993.
COST_REP_93:	Cost to repair damage that occurred in 1993 due to flooding.
#_PREV_FAIL:	Number of previous failures to have occurred in the history of the district.

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DATASET: 1993 FLOOD SCENARIOS

DOCUMENTATION DATE: April 19, 1995
DATA THEME: Boundaries
DESCRIPTION: The extent of flooding as determined by the UNET hydrologic computer model for different action alternatives and their affect on the Flood of 1993 peak flows.
ABSTRACT: These coverage's show the extent of flooding for eight different conditions, based on the flood of 1993 peak flows. They are as follows:

1) All Levees were built above the 1993 peak flood elevation.
2) The 1993 peak flows with a Manning coefficient of 0.08.
3) The 1993 peak flows with a Manning coefficient of 0.3.
4) All Agriculture levees have a 25 year event notch placed at the lower end of the levee system.
5) A 5% reduction in 1993 peak flows.
6) A 10% reduction in 1993 peak flows.
7) 1993 Flood with no flood fighting.
8) No reservoirs.

STATUS: Complete
GEOGRAPHIC AREA: The upper Mississippi, Missouri and Illinois Rivers respective floodplains.
MAP PROJECTIONS: Universal Transverse Mercator (UTM) zone 15.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION:ARC/INFO V.6.1.1, Sun Sparkstation

INTENDED USE OF DATA: This layer was designed as a means to provide information about the possible extent of flooding given different action alternatives during the peak flooding in 1993.
LIMITATIONS OF DATA: The positional accuracy of the coverage coordinates is a deductive estimate based on possible errors that may have occurred during each production step. These errors include source of data, and coordinate projection. The accuracy is estimated to be 100 feet.

COVERAGE DEVELOPERS: U.S. Army Corps of Engineers, Rock Island District
CONTACT: Tom DeWitte, US Army Corps of Engineers, Rock Island District, Operations Division, Clock Tower Building, P.O. Box 2004, Rock Island, IL 61204-2004. FAX: (309) 794-5191
E-MAIL: thomas@ncrsun2.ncr.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: paper
AUTHOR/AGENCY: US Army Corps of Engineers, Hydraulics Sections.
PUBLISHED DATES: 1994
SCALE: 1:24,000
PROJECTION: UTM zone 15, NAD27

PROCEDURE USED TO CREATE THE DATA: The US Army Corps of Engineers used the mathematical computer model program UNET, developed and programmed by Dr. Robert Barkau. This is a one-dimensional unsteady flow program. The UNET program was used to determine the water elevation at one-mile intervals along the three rivers. The hydraulic Engineers then transposed this information onto a series of USGS 7.5 minute maps using the topology on the maps a reference for delineating the "extent of flooding " for the different action-alternatives. These maps were then digitized into the ARC/INFO GIS system.
REVISIONS MADE TO DATA: none
REFERENCES: none
COMMENTS:none

Polygon Attribute File Items (PAT)
none

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DATASET: Corps of Engineers District Boundaries

DOCUMENTATION DATE: April 24, 1995
DATA THEME: boundaries
DESCRIPTION: US Army Corps of Engineers district boundaries for the continental United States.
ABSTRACT: This polygon based coverage shows the US Army Corps of Engineers civil works District boundaries for the continental US.

STATUS: 100%
GEOGRAPHIC AREA: continental United States
MAP PROJECTIONS: UTM Zone 15
MAP UNITS: Meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO v.6.1.1

INTENDED USE OF DATA: This data set is intended to be used to geographically locate the Corps Civil Works District boundaries.
LIMITATIONS OF DATA: Data meets National Mapping Accuracy Standards for 1:500,000 scale maps..

COVERAGE DEVELOPERS: Thomas DeWitte, US Army Corps of Engineers, Rock Island District, Engineering Division.
CONTACT:
Name: Thomas DeWitte, ED-DO
Address: Clock Tower Building
P.O. Box 2004
Rock Island, IL 61204-2004
Phone Number: (309)794-6153
Fax Number: (309)794-6050
E-Mail Address: thomas@ncrsun1.ncr.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Digital Arc/Info coverage of USGS drainage basins
AUTHOR: United States Geological Survey
PUBLISHED DATES: Unknown
SCALE: 1:250,000
PROJECTION: UTM Zone 15 NAD27.

PROCEDURE USED TO CREATE THE DATA:
The digital USGS hydrologic Unit Map (1:250,000) and the USGS 1:100,000 county and State lines map were used to extract the Corps of Engineers district boundaries. This is possible because all Corps Civil Works boundaries were originally based on drainage basins. This has altered slightly over the years. Thus the need for State and county line information.
REVISIONS MADE TO DATA: N/A
REVIEWS APPLIED TO THE DATA: 3/2/95 - Received comments for corrections from Omaha District. Corrections have been incorporated.
REFERENCES: N
COMMENTS

POLYGON ATTRIBUTE TABLE (PAT)
DISTRICT: The name of the Corps district.
DIVISION The name of the Corps division.

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DATASET: AIRPORTS

DOCUMENTATION DATE: April 19, 1995
DATA THEME: airports
DESCRIPTION: Landing facilities in the state of Iowa for various types of aircraft as supplied by the FAA..
ABSTRACT: The airports coverage contains points that represent the location of various landing facilities in Iowa. The types of landing facilities are airports, balloonports, seaplane base, gliderport, heliport, stolport, ultraport. It describes location, ownership, facilities, services, and activities information related to the landing facility.

STATUS: Done
GEOGRAPHIC AREA: State of Iowa
MAP PROJECTIONS: Universal Transversal Mercator (UTM) zone 15.
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO v. 6.1.1 Sun Sparkstation

INTENDED USE OF DATA: This data set is intended to be used to geographically locate landing facilities in the state of Iowa, and provide necessary information needed to contact the landing facility.
LIMITATIONS OF DATA: The coordinates locating the landing facilities were supplied by the Federal Aviation Administration (FAA). The point location is accessed to be within 100 feet of its true location on the face of the Earth.

COVERAGE DEVELOPERS: U.S. Army Corps of Engineers, Rock Island District.

CORPS CONTACT: Thomas DeWitte, US Army Corps of Engineers, Rock Island District, Operations Division, Clock Tower Building, P.O. Box 2004, Rock Island, IL 61204-2004. Phone # (309) 794-5674.
FAX: (309) 794-5191
E-MAIL: thomas@ncrsun2.ncr.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: electronic media
AUTHOR/AGENCY: Federal Aviation Administration
PUBLISHED DATE(S): March 3, 1994
PROJECTION: latitude-longitude

PROCEDURE USED TO CREATE THE DATA: The Corps of Engineers, Rock Island District received a 9 track tape containing the FAA file "Landing Facilities" in an ASCII format. The PC based program Microsoft Excel 5.0 was used to convert the space separated ASCII file into a comma delimited ASCII file. The comma delimited ASCII was then imported into ARC/INFO. The latitude, longitude coordinates were used to generate a point coverage in ARC/INFO. The FAA database contained a datafield which contained a unique identifier for each landing facility. The unique identifier was used to join the generated point coverage to the INFO database.

Point Attribute File Items (PAT): Eighty-eight items (excluded here for brevity) describing characteristics and capabilities of each airport are included in the PAT.

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DATASET: Hospitals

DOCUMENTATION DATE: April 19, 1995
DATA THEME: Critical Facilites
DESCRIPTION: Point coverage showing locations of hospitals in Iowa.
ABSTRACT: The hospitals coverage consists of point locations manually digitized from 1:24K USGS Quadrangles. Attribute data is derived from the "1994 Health Care Facilities In Iowa" book published by the Iowa Dept. of Inspections and Appeals, Division of Health Facilities.

"Hospital" means any place that is devoted primarily to the maintenance of facilities for the diagnosis, treatment or care of two or more non-related individuals suffering from illness, injury or deformity for a period exceeding 24 hours. It is also a place which is devoted primarily to the rendering of obstetrical or other medical/nursing care for two or more non-related individuals for a period exceeding 24 hours. It can be any institution, place, building or agency in which any accommodation is primarily maintained, furnished or offered for the care of two or more non-related aged or informed persons requiring or receiving chronic or convalescent care for a period exceeding 24 hours. Hospitals shall include sanitariums or other related institutions within the meaning of the federal Hill-Burton Act. A hospital shall include, in any event, any facilities wholly or partially constructed, or to be constructed, with federal assistance pursuant to Public Law 725, 79th Congress, approved August 13, 1946.

STATUS: 100%
GEOGRAPHIC AREA: Iowa
MAP PROJECTIONS: UTM Zone 15
MAP UNITS: Meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO v.6.1.1

INTENDED USE OF DATA: This data set is intended to be used to geographically locate hospitals and also provide necessary information needed to contact the hospitals.
LIMITATIONS OF DATA:The coverage depicts hospitals as a single point location. Frequently a hospital consists of more than one single structure. Only one point is used for each hospital regardless of the actual number of structures at the particular location.

COVERAGE DEVELOPERS: Robert Willhite, Steve Lindmark

CONTACT: Name: Robert Willhite, PD-W, Address: Clock Tower Building, P.O. Box 2004, Rock Island, IL 61204-2004, Phone Number: (309)794-5393, Fax Number: (309)794-5710
E-Mail Address: robert@ncrsun1.ncr.usace.army.mil

ORIGINAL SOURCE INFORMATION:
Media: 1:24,000 Quadrangles & 1994 Health Care Facilities in IA
Author/Agency: U.S. Geological Survey & IA Dept. of Inspections & Appeals, Division of Health Facilities
Published Dates:
Scale: 1:24,000
Projection:

PROCEDURE USED TO CREATE THE DATA: The corners of each Quadrangle were used as tics. Tics generated in Lat-Long coordinates. Tics & point locations then manually digitized from Quad maps. Digitized Quad maps then appended into one coverage. This coverage was then projected in UTM.
REVISIONS MADE TO DATA: N/A
REVIEWS APPLIED TO THE DATA: N/A
REFERENCES: N
COMMENTS

POINT ATTRIBUTE FILE ITEMS (PAT)
Hospitals-id : Unique identifying number
Name: Name of Hospital
Address: Mailing Address
City: Name of City
Zip Code: Postal Zip Code
Phone: Area Code and Phone Number

County: *County name in which hospital is located*
Quadmap: USGS Quadrangle digitized
CEO: Chief Executive Officer of hospital
Accreditation: JCAHO,AOA,NON-ACCREDITED.
Beds: Number of beds in the facility.

DATASET: Jails

DOCUMENTATION DATE: April 19, 1995
DATA THEME: Critical Facilites
DESCRIPTION: Point coverage showing locations of correctional facilites in Iowa.
ABSTRACT: The jails coverage consists of point locations on-screen digitized using 1:100,000 USGS DLG road coverages and a Iowa county polygon coverage as background coverages.

STATUS: 100%
GEOGRAPHIC AREA: Iowa
MAP PROJECTIONS: UTM Zone 15
MAP UNITS: Meters
DATUM: NAD27
SOFTWARE VERSION: ARC/INFO v.6.1.1

INTENDED USE OF DATA: This data set is intended to be used to geographically locate the county jails and state correctional facilities within Iowa.
LIMITATIONS OF DATA: The coverage depicts jails as a single point location. Frequently a jails consists of more than one single structure. Only one point is used for each jail regardless of the actual number of structures at the particular location.

COVERAGE DEVELOPERS: Robert Willhite, Steve Lindmark
CONTACT:
Name: Robert Willhite, PD-W, Clock Tower Building, P.O. Box 2004, Rock Island, IL 61204-2004, Phone Number: (309)794-5393, Fax Number: (309)794-5710
E-Mail Address: robert@ncrsun1.ncr.usace.army.mil

ORIGINAL SOURCE INFORMATION:
Department of Corrections, State of Iowa, Capital Annex, 523 East 12th Street, Des Moines, IA 50319

PROCEDURE USED TO CREATE THE DATA: The points were on-screen digitized with the aid of 1:100,000 scale DLG roads coverages as background coverages. With the corresponding background coverages a phone call was then placed to the corresponding correctional facility to verify the address and the location to place the point as close to its actual location as possible.
REVISIONS MADE TO DATA: N/A
REVIEWS APPLIED TO THE DATA: N/A
REFERENCES: N
COMMENTS

POINT ATTRIBUTE FILE ITEMS (PAT)

ia_jails-id : Unique identifying number
type: County or State government
Name: Name of the county or the name of the correctional facility.
Address: Mailing Address
City: Name of City
Zip Code: Postal Zip Code
Area Code: Telephone area code
Phone_#: 7 digit phone number
ac2: Fax's telephone area code
fax: Tele-fax machine number, if applicable
admin: Administrators name.
title: administrators title
inst_type: Applies to state correctional facilities only. Security level & gender.
capacity: Applies to state correctional facilities only. Maximum prisoner capacity.

DATASET: Schools

DOCUMENTATION DATE: May 13, 1994
DATA THEME: Critical Facilites
DESCRIPTION: Point coverage showing location of schools within the scope of FEMA-Iowa-GIS project.
ABSTRACT: The schools coverage consists of point locations manually digitized from 1:24K USGS Quadrangles. Attribute data is derived from dBase III file which is the database equivalent of the "1993-94 Educational Directory" for the Iowa Department of Education.

STATUS: 100% complete.
GEOGRAPHIC AREA: Mississippi, Missouri, Cedar, Des Moines, Iowa, Nishebotna, Sioux and Skunk River corridors in Iowa.
MAP PROJECTIONS:UTM zone 15
MAP UNITS:meters
DATUM:NAD27

SOFTWARE VERSION:ARC/INFO v.6.1.1

INTENDED USE OF DATA:This data set is intended to be used to geographically locate schools and provide necessary information needed to contact these schools.
LIMITATIONS OF DATA:The coverage depicts the schools as a single point location. Frequently a school consists of more than one structure. Frequently a school (especially the Community Colleges) consists of more than one structure.

COVERAGE DEVELOPERS: Robert Willhite, Steve Lindmark
CONTACT: Robert Willhite, PD-W, U.S. Army Corps of Engineers, Rock Island District, Clock Tower Building, P.O. Box 2004, Rock Island, IL 61204-2004, Phone Number: (309)794-5393, Fax (309)794-5710
E-Mail Address: robert@ncrsun1.ncr.usace.army.mil

ORIGINAL SOURCE INFORMATION:
Media: Pager Map 3-dBase III files provided on
1 floppy disk DIR9394.DBF SCHLKITC.DBF CROSWALK.DBF
Author/Agency: U.S. Geological Survey, Iowa
Department of Education, Census Data Center
Published Dates: 1948-1993 1993
Scale: 1:24,000 N/A
Projection: State plane N/A

PROCEDURE USED TO CREATE THE DATA: The corners of each Quadrangle were used as tics. Tics generated in Lat-Long coordinates. Tics and points then manually digitized from Quadrangles assigning a unique label-id to each school. Digitized Quadrangles were then appended. The resulting coveerage was then transformed to UTM coordinate system. The dBase files were converted to comma delimited ascii format and converted to an Info table. The Info table and point coverage were then joined with joinitem command using the label id as the related item.
REVISIONS MADE TO DATA: N/A
REVIEWS APPLIED TO THE DATA: N/A
REFERENCES: N/A
COMMENTS:

POINT ATTRIBUTE FILE ITEMS (PAT)
ia_schools_id: Unique label identification number
aea: Area Education Agency number
county: Iowa has 99 counties. They are numbered 1-99 in alphabetical order. See Iowa Official Register 1993-1994
district: school district number
nces: TIGER Census data school district number
school: Building or site number
name: Name of school
admin: Administrators name
title: Administrators title (i.e., Principal)
address: Address
city: City
zip_code: Zip Code
area_code: 3 digit area code
phone_#: 7 digit phone number
ac2: Area code for fax machine, if applicable
fax: Fax machine number, if applicable
gradespan: Gradespan
kitchen: On site Kitchen 'y'=yes; 'n'=no

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DATASET: Scanned 1:24,000 U.S.G.S quads.

DOCUMENTATION DATE: June 1, 1995
DATA THEME: 7-1/2 Minute Quad Base Maps
DESCRIPTION: Quad sheets for all quads covering the St. Paul District floodplain were scanned and rectified and Intergraph Design files were created. The area covers from Mankato, MN on the Minnesota River to the confluence with the Mississippi River and from there down river to Guttenberg, IA.
ABSTRACT: These files contain georeferenced Intergraph CIT raster images of 1:24,000 scale U.S.G.S. quad sheets.

STATUS: Done
GEOGRAPHIC AREA: Minnesota River (Mankato to St. Paul) and Mississippi River (St. Paul to Guttenberg, IA).
MAP PROJECTIONS: Albers Equal Area
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: Intergraph I/RAS B.

INTENDED USE OF DATA: This data was created for use as base maps for other Floodplain Management Assessment analyses.
LIMITATIONS OF DATA: Raster image is binary (black and white).

COVERAGE DEVELOPERS: U.S. Army Corps of Engineers, St. Paul District.
CORPS CONTACT: Terry Birkenstock, US Army Corps of Engineers, St. Paul District, Environmental Section, GIS Unit, 190 Fifth Street East, St. Paul, MN 55101. Phone # (612) 290-5271.
FAX: (612) 290-5800
E-MAIL: ncspetjb@smtp.ncd.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: Paper quad sheet
AUTHOR/AGENCY: U.S.G.S.

PUBLISHED DATE(S): various
SCALE:1:24,000
PROJECTION: N/A

PROCEDURE USED TO CREATE THE DATA: U.S.G.S. paper quad sheets were scanned at 400 dpi (Eagle Anatech Scanner), and georeferenced using a Albers Equal Area Projection with Intergraph I/RAS B software.

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DATASET: 1993 Flood outline

DOCUMENTATION DATE: June 1, 1995
DATA THEME: Flood Outline
DESCRIPTION: Flood extent boundaries were generated for the 1993 flood on the Minnesota River using aerial photography.
ABSTRACT: This coverage contains a polygon that represents the extent of flooding on the Minnesota River during the summer of 1993.

STATUS: Done
GEOGRAPHIC AREA: Mankato, MN to confluence with the Mississippi River.
MAP PROJECTIONS: Albers Equal Area
MAP UNITS: meters
DATUM: NAD27
SOFTWARE VERSION: Intergraph MGE and ESRI ARC/INFO.

INTENDED USE OF DATA: This data was generated in order to calculate the acres of various land cover types flooded for the Floosplain Management Assessment.
LIMITATIONS OF DATA: Data is intended for use in regional planning and is not considered more accurate than 1:100,000 scale data.

COVERAGE DEVELOPERS: Army Corps of Engineers, St. Paul District.
CORPS CONTACT: Terry Birkenstock, US Army Corps of Engineers, St. Paul District, Environmental Section, GIS Unit, 190 Fifth Street East, St. Paul, MN 55101. Phone # (612) 290-5271.
FAX: (612) 290-5800
E-MAIL: ncspetjb@smtp.ncd.usace.army.mil

ORIGINAL SOURCE INFORMATION:
MEDIA: 9x9 inch B/W aerial photographs
AUTHOR/AGENCY: Markhurd, Inc.
PUBLISHED DATE(S): 6/22/93
SCALE:1:20,000
PROJECTION:N/A
PROCEDURE USED TO CREATE THE DATA: Flood outlines visually interpreted and on-screen digitized onto scanned and rectified 1:24,000 scale U.S.G.S quad maps using Intergraph I/RAS B and Microstation software. The digitized polygon was imported into ARC/INFO as a DXF file and converted into a polygon coverage.

POLYGON ATTRIBUTE TABLE (PAT)
Flooded: The area considered covreed by the 1993 flood waters.

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NOTICE: The U.S. Army Corps of Engineers assumes no responsibility for errors in the information documented. Similarly the U.S. Army Corps of Engineers assumes no responsibility for the consequences of inappropriate uses or interpretations of the data made by anyone to whom this data has been made available. The Corps bears no responsibility to inform users of any changes made to this data. Anyone using this data is advised that precision implied by the coverage may far exceed actual precision. Comments on this data are invited and the Corps would appreciate that documented errors be brought to staff attention.

ATTACHMENT 9

FINDINGS

(Findings are also noted at the end of each chapter)

Chapter 1 - Flood Description

1-a) The 1993 flood was the greatest flood ever witnessed in some locations. The areal extent of the persistent rainfall and flooding was unprecedented. Over the nine-State region of the Upper Midwest, the USGS-measured discharges exceeded the 10-year event at 154 stream gaging stations, exceeded the 100-year event at 46 stations, and exceeded the flood of record at 42 stations (some of which have more than a century of data). Flood frequencies exceeded the 500-year event at some locations along the Missouri and Mississippi Rivers, as well as some of their tributaries.

1-b) Existing reservoirs provided $11 billion in damage prevention in the 1993 flood and reduced flood stages up to 5 feet in the main stem rivers. Three major urban levees/floodwalls in the St. Louis area would have overtopped without the reservoir reductions. Six levees in Kansas City would have overtopped without the Missouri River Basin reservoirs.

1-c) Damages of $4.1 billion are estimated to have been prevented by levees along the Missouri River, especially around the Kansas City metropolitan area. A significant portion of an estimated $3 billion in damages prevented around the St. Louis metropolitan area was attributable to levees. Another $1 billion or more in damages was prevented along the upper Mississippi River and tributaries in the Rock Island and St. Paul District areas.

1-d) Floods greater than the 1993 flood catastrophe will happen in the future. It would be prudent to prepare for future floods larger than the 1993 event. When we are properly prepared for catastrophic flood events, smaller floods will be more easily accommodated.

Chapter 2 - Forces Impacting Uses of the Floodplain

2-a) The upper and middle Mississippi River's landscape as it existed on the eve of the 1993 flood had, for the most part, been shaped by 1940, largely by navigation projects and agricultural levees. Urban projects had yet to be built. The greatest changes in the upper Mississippi River Basin after 1940 would occur in the river's tributaries and uplands. From 1960 to 1993, the Corps would build most of the urban projects and multiple purpose dams in the basin. The expected role of the Federal Government in protecting floodplain occupants evolved over the past 50 years. Floodplain regulation received little attention before 1960, but policies have been greatly expanded and institutionalized since the mid-1960's.

2-b) The Federal philosophy of floodplain management recognizes that flood damage avoidance should generally be the first defense against flooding, complemented by nonstructural and structural flood protection measures, where appropriate, with public education and flood insurance included as essential components to address the residual risk of flooding.

2-c) The inventory list compiled with this assessment of institutions, organizations, and interest groups is another step in further understanding of institutional forces. A more comprehensive analysis of the interaction of policies, programs, and goals of these "players" would add value to the understanding of floodplain management objectives.

Chapter 3 - Existing Resources and Impacts of the 1993 Flood

3-a) Floodplains provide opportunities for a wide range of outputs that include both private individual and societal benefits.

3-b) Land use differences between the two river systems and between upper and lower reaches are apparent. Agricultural uses account for over 77 percent of the Missouri River floodplain and 31 to 64 percent of the Mississippi River floodplain, depending on the reach. Wetland and Forest account for a higher percentage of land use on the Mississippi River (15 to 25 percent) than on the Missouri River (10 percent).

3-c) Extreme floods rework alluvial deposits on the floodplain, which is a disturbance process that typically creates new habitats for early successional biota. Short-term adverse impacts may occur, but the long-term effect is generally beneficial.

3-d) A flood is the major way that exchanges of nutrients, organic matter, and organisms take place between the main channel and lateral floodplain areas. Thus, even though levees do prevent some environmental damages, they also break the linkage of floodplain ecosystem components.

3-e) The extreme 1993 flood inundated a large percentage of the floodplain and demonstrated how plants and animals, adapted to a flood-pulse (especially fish), respond positively to floods.

3-f) Expenditures for the 1993 flood through the National Flood Insurance Program and the Federal Crop Insurance Corporation were less than half of the disaster aid payments made for human resources and agricultural needs.

3-g) At least 50 percent of total 1993 flood damages were agricultural.

3-h) Based on 1993 Federal Crop Insurance Corporation payments, at least 80 percent of the agricultural damages were caused by saturated soil conditions, lack of drainage, or other causes, not overbank flooding, and most of this would not have been affected by changes in floodplain management policies or programs.

3-i) For the 120 counties adjacent to the Upper Mississippi and Lower Missouri Rivers and several of their adjacent tributaries that were the focus of this assessment, urban damages substantially exceeded agricultural losses. Overbank flooding and problems associated with urban drainage and stormwater runoff continue to occur in a number of locations, as confirmed by the 1993 event.

3-j) Existing information and databases did not allow a comprehensive inventory of critical facilities subject to flood risk to be developed, nor to estimate costs to satisfactorily protect or relocate such facilities from flooding. A substantial amount of work remains to be accomplished to develop such information.

Chapter 7 - Evaluation of "Scenario Measures"

NATIONAL FLOOD INSURANCE

7-a) The definition of "floodplain location", using the 100 year flood outline, may not be adequate. Twenty-four percent of all losses covered by the NFIP for the years 1978 - 1993 were for damages outside (above) the 100 year floodplain. Some of these problem areas are related to high groundwater from heavy rainfall or poor interior drainage not directly related to a general condition of overbank flooding.

7-b) Compliance with prior flood insurance requirements has not always been adequate to ensure purchase of needed insurance. NFIP reform legislation in 1994 now requires lending institutions to ensure that flood insurance for mortgages on structures within the 100 year floodplain is obtained and maintained.

7-c) The Community Rating System (CRS) under the National Flood Insurance Program has potential to decrease the national exposure to flood risk by improving floodplain management and flood damage avoidance capabilities at the local level. The CRS is a program of the Federal Insurance Administration to award reductions in flood insurance premiums based on the effectiveness of a community's flood preparedness, damage reduction measures, mapping and regulations, and public information about flood hazards.

STATE & LOCAL FLOODPLAIN MANAGEMENT & ZONING REGULATIONS

7-d) State and local floodplain zoning ordinances and regulations could be most effective in determining the siting of critical facilities that have the potential for releasing toxic or hazardous elements into the environment when flooded.

7-e) Improved floodplain management, including land use planning, zoning, and enforcement at the local and state level, can reduce flood related damages. There are still communities and municipalities without zoning ordinances to reduce flood risks or plans to mitigate flood related damages.

RELOCATION, MITIGATION, & DISASTER RELIEF

7-f) Flood hazard mitigation options, particularly acquisitions (buyouts) of substantially damaged residential structures, have been a more prominent part of the Federal response in recovering from the 1993 Midwest flood. The process is underway for more than 8,000 parcels in the 1993 flood area (most are residential structures) to be acquired as part of the strategy to avoid repetitive flood damage in vulnerable floodplain locations. Close to $200 million, largely in FEMA Section 404 Hazard Mitigation Grant funds and HUD Community Development Block Grant funds, have been made available to pursue hazard mitigation projects in the 1993 flood area, with by far the largest share directed toward acquisition of damaged properties.

7-g) The Hazard Mitigation and Relocation Assistance Act was signed into law on December 3, 1993. It increased from 10 percent to 15 percent the share of total Federal disaster assistance that can be devoted to property acquisition and relocation projects, and increased the Federal cost share on eligible hazard mitigation and relocation projects from 50 percent to 75 percent. The additional funds and larger federal cost share in paying for the projects has significantly increased interest by the local governments and communities impacted.

7-h) The National Flood Insurance Reform legislation, Title V of the Riegle Community Development and Regulatory Improvement Act, was signed into law on September 23, 1994. Section 1367 establishes a new National Flood Mitigation Fund, with funding increasing to $20 million annually in FY 1996 and beyond, financed from NFIP premiums, to pursue future flood mitigation projects. Section 1366 provides up to $1.5 million annually from the National Flood Mitigation fund for mitigation planning assistance to states and communities.

7-i) Future Federal expenditures could be reduced by not providing disaster assistance for structures on Federally leased land (cottage leases along the Mississippi River). This could be implemented as a condition of lease renewal.

7-j) Future disaster assistance and insurance needs could be significantly reduced if the problem of repetitively damaged structures is firmly addressed through implementation of existing regulations by local, state, and Federal agencies.

7-k) More extensive reliance on flood insurance would better assure that those who invest, build, and live in the floodplain accept appropriate responsibility for the damages and other losses that result from floods.

7-l) More emphasis is now being placed on use of flood hazard mitigation measures, especially acquisitions of flood-prone structures, as an action that will reduce repeated Federal disaster expenditures and other costs associated with areas of widespread and potentially substantial repetitive flooding.

FLOODPLAIN RESTORATION

7-m) The difference between "natural floodplain restoration" and "wetland restoration" is an important distinction to make. Restoration of the natural floodplain requires changes in the levee system to restore natural hydrologic functions and create the linkage back to main channel areas.

7-n) Conversion of agricultural floodplain lands to wetlands and natural floodplain would have reduced payments for agricultural damages.

7-o) A stream restoration program that could enhance over 1,000 miles of tributary rivers and streams in each state in the FMPA study area would require a budget similar to the Wetland Reserve Program.

7-p) Wetland restoration programs are typically underfunded relative to the interest in participating in those programs.

7-q) A broader program to minimize the impact of local government's lost tax revenues resulting from land conversions would be beneficial and could reduce some of the opposition to these programs.

7-r) Conversion or restoration of a small percentage of agricultural land use to wetland or other natural conditions can significantly increase the existing percentage of natural floodplain acreage.

7-s) Current theories on floodplain function predict that the area needed for an improvement to the natural biota is probably fairly small and that restoration of a series of natural floodplain patches (a string of beads) connected by more restricted river corridors would be practical and beneficial.

7-t) Converting floodplain agricultural land to natural floodplain vegetation would not reduce stages but would marginally reduce damage payments in the 1993 Midwest Flood. Agricultural use of the floodplain is appropriate when the residual damage of flooding is understood and accepted within a financially sound program of crop insurance and flood damage reduction measures and when it is compatible with the risk to natural floodplain functions.

AGRICULTURAL SUPPORT POLICIES & CROP INSURANCE

7-u) The Federal Crop Insurance Reform Act of 1994 has replaced disaster assistance for agricultural crops with a prepaid insurance system for all farmers participating in other Federal farm programs.

7-v) The "Farm Bill" and associated incentives for production or set-aside can have a major effect on floodplain land-use and thereby, a major influence on the environmental quality of the floodplain-river system.

7-w) Use of acreage reserve, acquisition, and environmental restoration programs is an effective way to remove vulnerable agricultural production from marginal lands and to generate many environmental benefits.

7-x) Acreage reserve programs in upland areas have significant environmental benefits in the areas such as water quality, reduced sedimentation, increased wildlife habitat, and reduced peak runoff for local flood reduction benefit for frequent events, but do little to reduce stages on the mainstem rivers for catastrophic events.

7-y) Levee repair criteria are not sufficiently based on repetitive break history, maintenance history, environmental considerations, hydrologic analysis, economic analysis, or system-wide effect.

7-z) Although much progress has been made, in this assessment and before, towards completing a GIS based levee inventory, more needed work remains, especially concerning private levees, historic river configurations and hydrologic history, cultural resources, and environmental and economic land use.

7-aa) There is sufficient reason and support for State and Federal agencies to examine the justification for private levees that encroach the floodplain and diminish the integrity of Federal levees.

7-bb) There is ample evidence that a major problem with existing levees is that, in many cases, inadequate resources are being devoted to routine maintenance causing decreased levels of protection and increased interior ponding behind levees.

7-cc) Acquisition of marginal farmland and environmental restoration of that land should be evaluated on both a site by site and system wide basis. This will help ensure that the acquisitions are consistent with systemic management goals and to ensure that limited funds are spent most efficiently.

7-dd) The purchase of agricultural or developmental interests through buyout programs must take into account the needs of the seller and the local community, business community, and all taxing authorities to be well received and successful.

Chapter 8 - Hydraulic Modeling of "Action Alternatives"

8-a) All study computations were performed for the 1993 event only. Extrapolating conclusions obtained from analysis of 1993 event modeling may be erroneous with respect to other events.

8-b) From a hydraulic analysis perspective, the FPMA analysis illustrates that no single alternative provides beneficial results throughout the system. Applying a single policy system-wide may cause undesirable consequences at some locations. Examination of many factors such as computed peak stages, discharges, flooded area extent, and depth within flooded areas is necessary to evaluate how an alternative affects performance of the flood damage reduction system as a whole.

8-c) The importance of evaluating hydraulic impacts systemically is clear from the results of the unsteady-state hydraulic modeling. Changes that affect the timing of flood peaks or the "roughness coefficients" of the floodplain can be as significant as changes in storage volume.

8-d) Flood peaks may be reduced if increased floodplain storage is provided, and flood peaks may increase if storage volume is reduced (e.g. by levees constricting the river). However, the timing of flows from tributaries, or the effects on timing of flows due to increased storage, can be just as important, along with the "roughness coefficients" of the floodplain.

8-e) Levee profile surveys of all federal levees, an inventory and profile surveys of all private levees, and a data base on interior drainage and ponded areas are a prerequisite to being able to further advance the reliability of hydraulic modeling.

8-f) Some levee areas along the Missouri River experienced flood damage in the 1993 event as a result of the long duration of precipitation and flooding, exceeding the design standard of interior drainage facilities. Problems with interior drainage facilities also included sediment deposition, erosion, and deterioration of the structures since construction.

8-g) Hydraulic routings assuming agricultural levees are removed show that with continued farming in the floodplain, 1993 stages would be reduced an average of 2 to 4 feet on the Mississippi River in the St. Louis District. If this area would have returned to natural forested conditions, most of the system would still have shown reductions in stage (up to 2.8 feet), but increases in stages by up to 1.3 feet would also be seen in a few locations. In the Kansas City District, hydraulic modeling shows changes in stages of -3 to +1 foot for no levees with agricultural use and -3 to +4.5 change with forested floodplains.

8-h) If the agricultural levees along the Upper and Middle Mississippi River had been raised and strengthened to prevent overtopping in the 1993 event, the flood stages on the Middle Mississippi would have been an average of about 6 feet higher. Likewise, raising the levees to prevent overtopping on the Missouri River would have increased the stage by an average of 3 to 4 feet, with a maximum of 7.2 feet at Rulo, Nebraska, and 6.9 feet at Waverly, Missouri.

8-i) Although the Agricultural Levees Removed alternative with continued agricultural use of the floodplain shows the greatest stage reduction, exposure to flooding under this alternative is increased in the existing agricultural leveed areas. Risk of flooding at urban areas was shown to decrease or increase, depending upon impacts caused by factors such as hydrograph timing.

8-j) Although the Agricultural Levees Removed alternative with natural floodplains shows the least stage reduction, exposure to flooding under this alternative is decreased because the existing agricultural leveed areas would no longer exist. Risk of flooding at most urban areas would remain the same for this alternative.

8-k) Modeling results demonstrated that agricultural levee removal does not always provide uniform stage and discharge reduction. When levees are overtopped, they act as detention dams, skimming volume off the peak portion of the hydrograph. When levees are removed, the flow continues downstream in the enlarged floodway. As a result, higher flows may be experienced downstream at critical facilities and urban areas, causing increased stages at these locations.

8-l) Hydraulic modeling has shown that localized levee setbacks can increase flood stages downstream by creating a new bottleneck, and that a forested floodplain can increase stages similar to a levee constriction.

8-m) Hydraulic modeling of reducing the runoff from the upland watersheds by 5 and 10 percent predicted average stage decreases of about 0.7 and 1.6 feet, respectively, on the Upper and Middle Mississippi River and about 0.4 and 0.9 feet, respectively, on the Lower Missouri River. However, wetland restoration measures alone would not have achieved this level of runoff reduction for the 1993 event because of the extremely wet antecedent conditions. Restoration of upland wetlands would produce localized flood reduction benefits, but have little effect on mainstem flooding caused by the 1993 event.

8-n) Wetlands may reduce local flooding in the uplands by up to 25% where contributing areas are small. Restoration of such wetlands would not have impacted flooding in the lower floodplain reaches for the 1993 event because most depressional areas were already full of water throughout the watershed, as normally occurs during major flood events.

8-o) The potential to reduce flooding with further upland measures varies. In the watersheds that contributed the greatest percentage of runoff, wetlands and revised agricultural practices would have had minimal effect for the 1993 event. Major structural flood control storage reservoirs would be required to achieve the additional 10 percent volume reduction used for the analysis.

8-p) Several of the alternatives altered hydrograph timing. A complete evaluation is required prior to implementing any alternative to investigate performance for a variety of events with different inflow characteristics.

8-q) Results of the levee removal alternative illustrated that all model results which determine a stage and discharge reduction are extremely dependent upon assumptions regarding floodplain use and flow roughness. A change in channel or overbank roughness from the conditions assumed may significantly alter computed results.

Chapter 9 - Evaluation of "Action Alternatives"

9-a) The hydraulic routings performed as part of this assessment for the alternatives of removing reservoirs and removing levees verified that existing reservoirs and levees prevented considerable damage in the 1993 flood.

9-b) Without a detailed analysis of expected costs and benefits over time, it is impossible to determine whether a particular alternative is indicated for a particular site.

9-c) Benefits for one site are usually achieved partly by costs to another site. A system wide analysis is necessary.

9-d) One of the biggest sensitivities of results is to loss, or gain, in value of land due to changes in levels of protection, with indications that these could be very large numbers.

9-e) This assessment was not able to address combinations of alternatives, but further analyses may be warranted for combinations such as:

- Removing or setting back agricultural levees downstream of a community as a viable option to building higher urban levees;
- Removing agricultural levees in combination with localized protection of developed areas or floodproofing within the currently leveed areas; and,
- Reducing upland runoff in combination with minor improvements to an existing levee to achieve a higher and safer level of flood protection.

(The project costs would in the above cases include equitable compensation to those in the formerly leveed areas who would have increased risk of flooding)

AGRICULTURAL LEVEES

9-f) Alternatives such as Limiting Flood Fighting, Removing Agricultural Levees (with land use remaining agricultural), and 25-year Maximum Height Levees, appear to have little net potential for reducing flood impacts. While flood stages would be somewhat reduced for these three alternatives, providing some minor reduction in non-agricultural impacts, total area flooded would increase dramatically.

9-g) Preparation of a fully coordinated and comprehensive plan for conducting future flood fight efforts, which includes consideration of when to cease or limit Corps flood fight assistance, would be a valuable tool for improving future flood responses.

9-h) The estimated costs are $5.6 billion for raising all agricultural levees to contain the 1993 flood in just the St. Louis District. While virtually all of the agricultural levee damage would be prevented, much of the urban flood protection would have been placed at risk and substantially more of the unprotected urban development in the City of St. Louis, St. Louis County, and St. Charles County would be more severely damaged. Approximately 60 miles of unprotected Mississippi River floodplain below St. Louis with many rural and suburban communities, would also suffer substantially increased flood damages.

9-i) The levee setback case study illustrated that setbacks of a particular Omaha District federal levee would have prevented overtopping of that levee during the 1993 event. However, levee setbacks were also shown to have undesirable consequences such as major losses of agricultural benefits over the life of the project. If levee setback distance is such that the levee no longer overtops, results showed that a downstream rise in flow and stage is caused at the next river constriction. It is also possible that increased vegetative growth between the levee and river would increase roughness and offset some effects of the levee setback. In addition, negative impacts to interior drainage would include a longer outlet channel to discharge into the river requiring increased maintenance due to siltation.

9-j) Adopting a standard 25-year level of protection for all agricultural levees prior to the 1993 flood event would have resulted in an average stage reduction of about 3.5 feet on the Middle/Upper Mississippi River and about 2 feet on the Missouri River near its mouth. This decision would require implementation funding in the billions of dollars for structural modifications and real estate interests and would have resulted in significantly increased 1993 agricultural flood damages.

9-k) Interior ponding behind levees is a considerable problem for all flood events but is of particular significance in a large flood, with heavy, prolonged regional precipitation like that experienced in 1993.

CHANNELIZATION AND URBAN LEVEES

9-l) There is great potential for significant flood damage in the older established cities with extensive unprotected infrastructure investments in the floodplain and critical facilities that, if flooded, could release harmful substances into the river.

9-m) The 100-year level of protection often provides a false sense of security. The Chesterfield-Monarch area, located near St. Louis, experienced $520 million damages in 1993 despite 100-year private levee protection. Also, providing a levee with only a 100-year level of protection in an urban area allows for unrestricted development within the protected area. When the 100-year flood event is exceeded, the resulting flood damages and potential for loss of life could be catastrophic. Consideration should be given to such possible consequences of exceeding the 100-year flood.

UPLAND RETENTION/WATERSHED MEASURES

9-n) The ability of reservoirs to hold back very large volumes of runoff and thus substantially reduce downstream flooding was again proven by the 1993 flood event.

9-o) Although upland retention alternatives do not indicate major changes in floodplain impact categories, there are significant changes that could result throughout the watershed-floodplain-river system depending on the type of retention measures used.

9-p) In some situations, reservoirs may be the most cost effective and low risk means of reducing flood stages on major rivers; however, site availability and environmental concerns generally make this option non-implementable.

Chapter 10 - Other Separate Issues Investigated

COST DIFFERENCES BETWEEN UPPER AND LOWER MISSISSIPPI RIVER

10-a) The upper Mississippi River, above the Missouri River at St. Louis, exhibits characteristics considerably different from the middle and lower Mississippi River, due to: a relatively narrower floodplain; and, a relatively stable channel alignment that is well defined by existing navigation locks, dams and pools.

10-b) The middle Mississippi River (St. Louis to Cairo, Illinois), is subject to flood events with greater discharge than the upper Mississippi River (above St. Louis).

10-c) Extending the lower Mississippi River's system approach upstream throughout the middle Mississippi River for a dual flood control and navigation purpose is engineeringly feasible, but would require specific Congressional direction and may not be economically feasible because the estimated costs are approximately $5.7 billion.

RESPONSIBILITY FOR REPAIR OF LEVEE EROSION CONSISTENT AND FAIR?

10-d) The responsibility for repair of levees is not consistent between various federal agencies.

10-e) It is the intent of the Corps of Engineers to apply its levee erosion repair policies in a consistent manner throughout the United States.

IMPACT OF REVISED ANTECEDENT CONDITIONS ON THE MISSOURI RIVER

10-f) On the Missouri River, additional releases would not have been required if the pool levels had been at normal levels. Therefore, there would not have been greater damages if wetter antecedent conditions had preceded the 1993 flood.

IMPACT OF BRIDGES

10-g) Even in an event as massive and widespread as the 1993 flood, the effects of bridges are essentially isolated and unique to each bridge and its associated floodplain. Some bridges designed to produce no increase in the 100-year flood profile did produce increased upstream stages when they could not pass the much larger 1993 flood flow, but the effect was primarily localized.

STATE AND LOCAL FLOODPLAIN MANAGEMENT & ZONING REGULATIONS

10-h) With the exception of the State of Missouri, the states studied under this assessment have viable floodplain management programs. Their floodplain zoning regulations are consistent with those set forth in model ordinances, and in some instances are more stringent. The states of Iowa, Minnesota, Nebraska, and Wisconsin currently exceed the NFIP minimum zoning standards for floodway, 100-year flood elevation, and critical facility siting and protection.

10-i) Among the seven FPMA States, annual funding to administer floodplain management ranges from $35,000 to $1 million (1991); the average is about $400,000.

10-j) The State of Missouri has focussed its efforts since the "Flood of 93" on acquiring and relocating at risk structures in the floodplain, giving it one of the most aggressive programs reviewed. The Missouri program will acquire or relocate 4,143 structures. The State is also in the process of reviewing legislation to implement a model floodplain zoning ordinance in an effort to establish a state-level program.

10-k) The States of Illinois, Iowa, Kansas, Minnesota and Wisconsin have also developed aggressive acquisition and relocation programs to reduce the level of flood damages experienced during the 1993 flooding. In particular, the states of Illinois, Minnesota and Wisconsin have created state-level programs to fund mitigation activities.

10-l) The state floodplain management programs reviewed provide a good framework for regulating development within floodways and the 100-year floodplain. They do not provide guidance for the protection of residential and non-critical facilities located between the 100-year and 500-year flood elevations.

10-m) Federal agencies could be more efficient in responding to disasters and funding issues if standard procedures could be used, which would also provide a framework for state regulators to improve their programs as a group.

10-n) Floodplain managers believe that there is much to be gained if existing Federal, State, and local rules and regulations concerning floodplain management, land use, and zoning requirements were followed, even without stricter Federal guidelines.

INDUCED DEVELOPMENT

10-o) Past Federal actions to insure or provide disaster assistance for vulnerable floodplain locations have contributed to more intensive use and subsequent exposure to flood damages than would otherwise have been the case.

10-p) Structural flood protection projects have tended to induce floodplain development beyond what otherwise would have taken place, and the effects of such inducement have frequently not been well accounted for. In most areas, however, development preceded the installation of flood protection works. The Principles and Guidelines for Federal water resources planning permit a detailed examination of the effects of induced development.

10-q) More comprehensive economic evaluations in flood control studies would help to explicitly address the benefits and costs associated with development in floodplain locations. A rational system of floodplain management would require new activities in floodplain locations to: a) self-cover all losses that will be incurred when a flood strikes, or b) pay for flood insurance on a continuing basis to cover such losses.

10-r) Exposure to risk in the floodplain, and associated flood damages, are now too often considered as an "externality", a cost that society is asked to pay when the "unexpected" flood strikes. Unless those who invest and locate in the floodplain are able to assume the costs of flood damages themselves, or insure against these risks, the rest of society (i.e., government and taxpayers) is subsidizing potentially unwise investment decisions.

IMPROVEMENTS TO MODELING

10-s) The Corps of Engineers has now developed UNET models of the Mississippi River from St. Paul, Minnesota, to Cairo, Illinois, and of the Missouri River from Omaha, Nebraska, to St. Louis, Missouri. Further refinement of these models and extending them to critical river reaches not yet modeled will require significant additional basic data.

10-t) The FPMA modeling has shown that some changes on the Mississippi and Missouri Rivers have system-wide effects. The UNET model is an appropriate tool to analyze these effects.

LEVEES PART OF NAVIGATION SYSTEM?

10-u) Levees may be considered to be part of the navigation system in a limited set of circumstances. However, during the establishment of the nine-foot project, each lock and dam site was evaluated and structures necessary to maintain navigation were built, and are currently being maintained, by the Corps of Engineers.

IMPACT OF NAVIGATION STRUCTURES

10-v) Sedimentation in backwater areas, navigation dams, and channel training structures do not have an impact on flooding on the Upper Mississippi River. Channelization along the lower Missouri River needs to be studied in greater depth in order to conclusively determine its effect on flooding.

Chapter 11 - Desires of Affected Interests

11-a) Comments heard and read throughout the public involvement process confirmed strong support for three main themes: 1) levees among agricultural interests, 2) non-structural measures and upland watershed management plans by all interests, and 3) agricultural, environmental, and government representatives are asking for greater coordination among agencies responsible for managing the Upper Mississippi and Lower Missouri Rivers.

11-b) Overwhelmingly, the priority response throughout the region, at the April 1995 public meetings, was to 1) protect critical facilities and 2) use upland retention and additional watershed measures.

11-c) The success of any change in floodplain management will require complex coordination between all concerned interests (public agencies, private interest groups/organizations, and local communities). Throughout all the meetings and from written correspondence, interest groups were asking for the opportunity for more involvement in the assessment process. Partnering efforts to determine future management options were mentioned often.

11-d) Desire for total watershed management was as strong an issue as the desire for structural flood control.

11-e) Any relocation/mitigation program needs to provide financial resources for planning to assure cohesiveness of the affected community.

Confluence of Missouri and Mississippi Rivers